Università degli Studi di Ferrara

DOTTORATO DI RICERCA IN
"Economia"

CICLO XXVIII

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Municipal Waste Economics in Europe
Market structure, empirical insights, and innovation

Settore Scientifico Disciplinare SECS/P-06

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Anni 2013/2015

Be curious,
Though interfering friends may frown.
Get furious
At each attempt to hold you down.

If this advice you always employ
The future can offer you infinite joy
And merriment,

Experiment
And you'll see

Cole Porter, *Experiment*, 1933

Acknowledgements

So many people helped me in writing this work (a real waste of intelligence!).

Besides of my mentor, Massimiliano Mazzanti, I am very pleased to acknowledge Professors and colleagues at Department of Economics and Management of the University of Ferrara (Susanna Mancinelli, Giovanni Masino, Lucio Poma, Marco Di Tommaso, Francesco Nicolli, Marianna Gilli, and Claudia Ghisetti) for the useful comments and suggestions.

Other hints and inspiration on the econometric estimation of the model came from Tommaso Reggiani (University of Koeln) and Emanuele Bacchiocchi (University of Milan).

I owe a special recognition to Antonio Massarutto (University of Udine), Carlo Reggiani (University of Manchester), Giuseppe Lucio Gaeta (University of Naples “L’Orientale”), and Stefano Ghinoi (University of Bologna) who helped me to develop some parts of the research with useful comments, and decided to assume the discomforting position of co-authors in three different articles I extracted from this work.

Finally, a special tribute to Giacomo Calzolari (University of Bologna) and Massimo Motta (Universitat Pompeu Fabra), without whom this work would have never been started.

But this is not an accusation of complicity, and the usual disclaimer applies.

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Introduction: the Waste Issue

According to many psychologists and sociologists waste is the most fitting representation of modern times, an issue that goes to the heart of human common living: economic growth generates material well-being, but even environmental illness. Waste quantities increase is a signal that while richness and consumption patterns are getting better, air and water quality, soil consumption, and environment as a whole are under high pressure.

This well known, contradictory connection between human development and scrap generation points out that the waste issue involves a deep revision of individuals' style-of-life: not only the introduction of soil-saving waste disposal solutions, such as incinerating, or with a lower environmental impact, such as re-use and recycling, but a new conception in goods provision is needed: a rethinking that calls for both an higher attention of producers in goods preparation (beginning from a reduction in packaging), and a change in personal behaviours of consumers.

Waste is something the man rejects: in most languages throughout the world, the term for "waste" and "rejection" is the same. It is something man wants to turn away from himself with any modality, and until few years ago, it was handled "out of sight", during the night. It is a remote notion, something to be dealt with by somebody else on our behalf, and to be remitted to an impersonal good as the environment.

This picture changes when we get aware of the way in which goods and services are produced, of their real utility, and of the total impact on environment of their use and disposal. This means operating to reduce row materials contained in goods, to turn their use more rational, in short to enter in the ethical perspective of inter-generational justice.

But symbolism of wastefulness still prevails, transforming waste in a social conflict issue: luxury, unconventionality, power, are all parts of a coveted lifestyle opposite to sobriety and frugality, the last ones perceived as something retrograde, a losers' attitude.

Another strong social conflict related to waste arises anytime a new location for a disposal facility is prospected (a landfill, an incinerator, even a biomass energy producer fed with agriculture and livestock scrap). This kind of reaction is well known in literature, labelled since 1980's article by Emilie Travel Livezey as "Not In My Back Yard (NIMBY) syndrome"[1]. It is an understandable position, even though the same vehemence addressed to waste facilities or to some other public work is not devoted to even more pollutant activities, such as traffic infrastructures or industrial plants.

Waste is a subject that generates conflicts and opposition, and that asks for sharing responsibility and feeling part of a community. It implies reliance and cooperation among any kind of stakeholder: public administrators, that ought to find solutions with transparency and not ignoring fears and doubts from local communities; producers, that ought to rethink goods' design to reduce end-of-the-pipe waste, extend commodities' life and bear the cost of correct disposal; citizens, that ought to join a more frugal lifestyle, be free from preconceptions when discussing different solutions, and to collaborate in making the picked solution more efficient; finally, an important role in the waste issue is played by non-governmental parties (NGO), like environmentalist and consumers associations, and social cooperatives. NGO are involved mostly in denouncing bad administration and crimes in waste management (from illegal disposal to the extreme case of "eco-mafia", i.e. the presence of criminal groups in the waste chain), but they play even an educational role for citizens and a motivational one for public administrations. Social cooperatives, being social because they are

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[1] Emilie Travel Livezey, *Hazardous waste*, The Christian Science Monitor, November 6th 1980.

aimed at including disadvantaged people in the job market, are deeply involved in materials recover and waste collection, generating what sociologists labelled as “triple dividend” (Osti, 2002), recalling the renowned notion of double dividend (Tullock, 1967): besides of an economic outcome (the salary and the value chain produced by work activity), and an environmental one (reducing end-of-the-pipe waste), a third dividend is added, namely the bonus of restoring dignity and acceptance to social outcasts, generating the intimate reward of behaving as a “good citizen” (“warm glow” effect)[2].

Managing waste means to start a group action that involves society as a whole, with all its elements: citizens, companies, public administrations, NGOs. Waste is a progressively more complex issue, and it must be dealt with producing a joint effort in the name of a new, inclusive way of life.

For all those reasons, Municipal (or solid) Waste (hereafter MW), i.e. the stream of garbage produced by households, is one of the main issues in modern life from many perspectives, deserving studies of different kinds: sociologic, engineering, by environmental science, and economic.

As a matter of fact, the waste issue evolved in last 60 years from a mere local hygiene perspective to an environmental policy problem, with a growing degree of complexity, and a growing involvement of the economic science to deal with it.

Nowadays, waste economics regard many different and challenging subjects: the transition from a micro level perspective (the waste issue as a local community problem) to a macro level one (the waste issue as a global problem in terms of resource efficiency); the opportunity to allow or to ban the waste trade between territories (efficiency by specialization versus the risk of generating waste havens).

But the most interesting economic topic related to MW, albeit still quite neglected, is probably its treatment as an Industrial Organization issue, likewise many other public utility services, from telecommunication to energy provision: the existing relationship among the segments of the MW chain, with different degrees of openness and the persistence of incumbents and monopolistic agents; the regulation of the access to last resort plants as “essential facilities” and the obligation to provide public services; the evolution of the relationship between the provider and the end user, a matter commonly labelled as “last mile” issue in the public utility studies, that concerns the implementation of different home selection systems and the study of progressively more sophisticated schemes of pricing. Finally, the spread of innovation and its contribution to MW industry productivity.

As a consequence, with this work we give a contribution to MW studies from an industrial organization perspective, focusing mainly on the European market. To develop this subject, the following pages are organized as follows.

In Chapter 1 we describe the European MW organization, from the nature of the service to the illustration of the market’s features; in this first chapter we deal with the fundamental issue of European Union rules and principles that regulate the MW industry.

Chapter 2 sketches the theoretical framework and the literature review of the work, represented by the three branches of Regulatory Economics, Waste Economics, and Economics of Innovation, whose main literature contributions are cited

Chapter 3 is the core of the whole research: it introduces a mathematical formalization to describe the functioning of MW industry as the result of three interlinked segments (waste selection, waste collection, and waste disposal), focusing on a number of issues: the degree of competition in the market of disposal, the welfare effects of current regulation and the consequences of a possible relaxation of it, the consideration of disposing services with different technical efficiency.

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[2] Another social dividend related to waste management and encompassed in the sorted collection issue is the offsetting of what is called “Accumulation by contamination”, i.e. the process by which the capital system socializes costs, through successful costs-shifting (Demaria, Tasheva, and Hlebarov, 2012).

Chapter 4 is dedicated to quantitative analysis. We begin with the estimation of one of the most relevant equations of the model, and we follow finding evidence in the correlation among recycling and other variables of socio-economic, geographical and political nature. To this purpose, we built a data base with 1,522 cross sectional observations from Lombardy, the Italian region with the highest number of municipalities and inhabitants, and with the highest per-capita revenue, besides its long-run practice in MW management.

Chapter 5 deals with a very neglected issue, i.e. the role of innovation and technical change in the MW industry.

Even though each chapter ends with a section of final remarks, a chapter of Conclusions collects and highlights the main results of the study.

From the whole research, we can highlight the following results:

Chapter 1 (European MW industry):

1. MW management evolved through last 40 years from a social and health matter to an industrial organization issue, involving different kinds of operators, technologies and organizational questions;
2. due to this evolution, nowadays MW management is a subject at the intersection between Environmental Economics and Industrial Organization, to be treated with the tools of both economic theory branches;
3. EU MW industry is based upon three main pillars:
    a. "The Ladder (or Hierarchy) Principle", meaning choices should prioritize waste reduction just from goods production, then reuse, recycling, energy or downgrade recovery, and, residual, landfilling/incineration;
    b. "The Extended Responsibility Principle" (ERP), i.e. all operators acting along the production and retaliation chains are responsible for the final disposing of goods when transformed in end-of-the-cycle waste;
    c. "The Proximity/Self-Sufficiency Principle" (PP/SSP), i.e. MW must be handled as close as possible to the place where it is generated.

Chapter 2 (Literature review):

4. although dealing with many utility and network industries such as telecommunication, electricity, gas and water supply, regulation theory and competition studies ignore MW industry;
5. in the same way, MW industrial organization is still neglected by waste economics, that rather focus on empirical studies on recycling, relations between national income and waste production or end-of-the-pipe disposal (the so called "Waste Kuznets Curve"), and waste trade;
6. being more prone to cumulative innovations historically and socially determined, the kind of technical changes involving MW industry are better explained by heterodox approaches, rather than by neoclassical innovation economics.

Chapter 3 (A model of the MW Industry):

7. a complete formalization of MW sector as a multi-stage industry is given for the first time, both in a spatial and a non-spatial framework, allowing to watch at the mutual influence of different segments and operators (namely a local community of households, a MW collection company, and a MW disposing facility);
8. a higher competition in the disposal segment induces the Collector to shift from waste selection to landfill disposing. The final consequence is a higher generation of unselected MW, and of the related environmental externalities;

9. strategies such as vertical integration of Collector and Disposer or the implementation of waste-to-energy technology are studied; we discover they are detrimental to MW selection and foster end-of-the pipe disposal;
10. at least the same total welfare generated with regulation (implementation of PP/SSP) is achievable imposing in an open MW market a Pigouvian tax, for instance a landfill tax levied either on the Disposer or on the Collector;
11. removal of PP/SSP is still compatible with an increase in selected MW whenever some element of asymmetry is introduced, for instance a sole disposing facility serving two areas or different skills in recycling of two cities.

Chapter 4 (Empirical estimation)

12. using cross-sectional data from Lombardy (see Appendix A.2), the model introduced in Chapter 3 fits with the explication of the correlation between recycling percentage, households effort and capital provided by the collection company, and with the function correlating unsorted waste with market openness and the cost of MW management. Nonetheless, the cost of MW management service is non significant;
13. using the same data set, we detect positive and significant correlation between MW selection and the ruling of the Municipality by a left-wing coalition;
14. we find a lower elasticity of MW selection with respect to geographical variables, higher with respect to socio-economic ones. Nonetheless, quite in contrast with standard literature we detect negligible correlation between MW selection and education;
15. we discover a counter-intuitive correlation between percentage of selection and the distance from the assigned disposal facility, motivating this outcome with disposal market foreclosure, and between the same independent variable and municipal real estate values, motivating it with inflated values generated by tourist destinations.

Chapter 5 (Innovation in the MW industry)

16. main innovations in MW industry are of different kinds:
    a. process innovations given by waste to energy technologies, RDF, plasma-torch incinerators, pre-paid waste bags, transponders and RFID devices to track waste transfers, electronic street dumpsters;
    b. product innovations given by eco-designed, dematerialized, repeated use, energy savers goods;
    c. organization innovations given by vertical and horizontal mergers in MW industry, new collection schemes (door to door, kerbside, by ecomobiles or even by mule collection), payment schemes such as Pay As You Throw (PAYT) system.
17. drastic innovation, technological change, R&D investments and patent applications are not compatible with MW industry, where innovations are mostly of a non-drastic kind, R&D investments are low, innovation is policy- rather than market-driven;
18. taking the approach of Complexity theory to innovation, we identify four emerging “market systems” in MW industry, namely the “traditional”, the “waste-to-energy”, the “light recycling”, and the “hard recycling” market systems.

As made it clear in preceding lines, this work is structured as a single thesis where all chapters are concatenated, from Introduction to Conclusions. Nonetheless, it is easy to elicit from it three main topics, each of them treated in a dedicated essay: they are the model representation of MW market (Chapter 3), the estimation of socio-economic and political drivers of waste selection (Chapter 4), and the study of innovation in MW industry (Chapter 5).

Chapter 1:
The Municipal Waste Industry in Europe

In this Chapter we describe the main features of the MW industry in Europe.

In Section 1.1, we explore the economic nature of the MW management service; bringing to light the puzzling evidence of a service with characteristics of a private good, however provided under strict regulation with interventions typical of public goods.

In order to better understand the rationale of the current market organization, we briefly depict the historical evolution of the European waste industry throughout the last 50 years (Section 1.2).

Section 1.3 describes and provides an analysis of the sector regulation framework according to European Union directives, devoting particular emphasis on the Principles that characterize the latest EU waste policy.

The final result of both the historical evolution and the EU regulatory framework is provided from a practical (Section 1.4) and a general perspective (Section 1.5). In the first section we observe the trends and figures that characterize European Countries (with a focus on Italy); in the second one, looking at the relationship between different segments of the industry (collection, disposal, recycling) and different actors of the waste chain (regulators, municipalities, collectors and disposers) within the framework of integrated waste management.

Section 1.6 deals with competition in MW industry, introducing the issue and the challenges that are the object of the model discussed in Chapter 3.

Finally, Section 1.7 addresses some open questions to be taken into consideration in the future.

1.1 The Nature of MW management

Standard public sector economics developed a theory of market failures in order to justify the role of the Public sector in the economy, grouping them in a series of well known categories according to their degree of rivalry and excludability, namely pure public goods, commons, club goods, and private goods.

The following graph gives a direct representation of the issue:

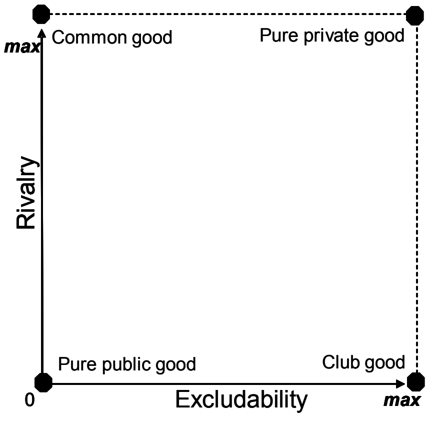

Fig. 1.1.1: A general representation of the economic classification of goods

Another field of public intervention is the so-called merit goods, i. e. those goods whose utility is systematically underestimated by consumers that do not express an adequate willingness to pay for them.

Other varieties of market failures claiming public intervention are related to market mechanisms rather than to the nature of the good itself, dealing with externalities, both environmental and social. Finally, State interference is suggested for distributive purposes, any time a more equitable and socially acceptable distribution of costs and benefits inside the society is needed. The objective could be reached not only through taxation, but even through the free provision of a set of basic goods or services (Guesnerie and Roberts, 1984).

Moreover, European Union regulation[3] distinguishes between "Service of general interest", like museums and culture, health, social care, i. e. the merit goods we previously mentioned, and "Service of economic interest" which include market and profit-oriented activities. In any given industry, a general interest can emerge whenever one or more of these categories are present. This peculiarity is relevant in choosing alternative models available, that should be consider, not only efficiency issues in meeting consumers demand, but should also be able to meet all environmental requirements, both taking into account normative regulation and socio-economical proactive considerations. This insight provided the theoretical justification for the massive expansion of the role of Government in the economy within the last thirty years, in particular in the field of public utilities.

Compared with other utilities, such as energy or water provision, MW management service has a stronger emphasis on the nature of public good, even if the strict activity of removing waste from the place where it is generated can be considered a whole private good. It is, in fact, the way it is later handled and eliminated that is a collective concern, due to the externalities it can generate.

In the collection market, public good dimensions arise from urban neatness and public health, as well as by the collective achievement of environmental policy objectives such as recycling targets (Ascari *et al.*, 1992). Rivalry in access to the network is limited and restricted to the availability of street dumpsters, high enforcement costs, and suspending the service to those who do not pay is realistically unfeasible (Kinnaman and Fullerton, 1999); as a consequence, individuals may easily abuse the system by engaging in illegal or improper practices, whose restrictions are in themselves problematic and expensive.

Empirical evidence on the true relevance of these issues is contrasting. On one hand, individual advantage of free-riding are modest, since the monetary cost of the service is not particularly high, and illegal practices presume further complications and costly activities (such as dumping garbage in an uncontrolled site at night or managing an unofficial landfill) that, once discovered, result in social, normative, and monetary sanctions. This risk could be reduced, but not totally eliminated, if all households were compelled to choose among authorized operators providing evidence that they had done so, as is the case for special/industrial waste (See *infra*).

Finally, the distinction between general and economic interest services, with the latter to be run by a market oriented company, may seem easy to grasp from a theoretical point of view, but brings in many questions when applied in real life. This is typical of services such as water supply or MW management, where the relevance of the good in relation to public health recommends to keep it in the domain of public administrations, while the need of economic effectiveness in providing it, the obligation of remunerating inputs and investments, and the existence of a high demand for the service differentiates it as a private good to be supplied by firms in a competitive framework.

In brief, from a theoretical point of view, MW management service shows the standard features of a private good, including both rivalry and excludability available, and a strong emphasis on economic interest.. Given this, it should operate as a full private market, subjected to demand and supply law and open to competition. However, due to the potential externalities in waste elimination, the sector is strictly regulated with intervention of public players, at least in Europe.

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[3] COM 2004/374 Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions - White Paper on services of general interest.

In order to better understand its functioning, further insight in the regulation issue is necessary as well as a brief historical reconstruction of waste management in European towns.

1.2 The Evolution of MW management through time

The waste issue is rooted in the history of human society. Since Ancient times, vast urban areas such as Rome perceived the need to organize the collection and evacuation of scrap materials in order not to impede the health of its citizens. In the Middle Ages, the accumulation of wreckages (bricks, pot fragments, ashes) led to the rise of the ground level in every town and city. In the XIX Century, the removal of human and animal excrements from urban areas continues to be the main waste problem to deal with. The Industrial Age introduced the issue concerning solid waste. However, it is not until the post war era, which led way to demographic expansion and the economic boom, that the amount of materials and goods introduced in towns to satisfy the needs of the urban population were no longer able to be absorbed into "urban ecosystem". Consequently, local authorities had to adopt public systems to transport residual material outside the built-up area where available wide open spaces existed in order to dispose of solid waste. mainly in the empty holes and pits left by the increasing number of exhausted quarries that are generally used to feed the construction industry. However, as the quantity of waste increased, as a result of overt consumerism coupled with urban sprawl, availability of empty spaces for the disposal of waste reduced, forcing towns to search for sites farther out of town willing to host their garbage. As a consequence, at the beginning of the 1960s many European Municipalities, mostly large in size, started to explore the option of burning waste. The simple waste incineration however proves to have a hazardous outcome on public health and the environment, due to dioxin emission, leading to new legislations imposed on the waste industry including new laws imposing emission filters and depuration systems to plant facilities, while open air disposal is subdued by licenses and permanent controls on landfills. In those years, a progressively more worried civil society lobbied for alternatives to end-of-the-pipe solutions, such as sorted collection and recycling.

In last 40 years, the MW management market has gone through an intense transformation, from a low-added value and labour intensive service dominated by collection into a complex industrial activity focused on the post-collection phases of recycling and disposal, bringing about significant investment, specialization, management skills and technological innovations within the market.

Until the 1970s, MW management was a straightforward low-added value labour-intensive activity, with manageable amount of waste volume, cheap disposal technologies and limited to landfills, as well as an already existing viable "recycling" system as a result of the positive economic value of rejected materials (mostly iron scraps, wood and paper) feeding nutshell business. At that time, MW management was still considered as an issue of hygiene and public health at a urban level, aimed at providing a public good to citizens, the rationale being the there exists a correlation between the hazardous nature of waste and the spread of contagious diseases.

The environmental crisis of the 1970s significantly contributes to changing this landscape. After many years of growing welfare and consumer consumption, waste generation in industrialized economies increased exponentially, adding pressures on the disposal system. The most commonly used type of facilities – landfill sites – displayed the growing problems concerning capacity constraints, while a increased attention for, and equal reaction against, any kind of polluting plant made it progressively more difficult to establish any new incinerators. New schemes for recycling and reuse, reluctantly introduced that attempted to address total quantity of disposal waste reduction as well as related external costs.

In those years, the key notion in MW management begins to shift from public health to the responsibility for natural resources, expanding the geographical scale of MW management from urban to regional and introducing treatment technologies outside the end-of-the-pipe rationale, even when landfill dominance persists. The "waste-chain" continues to grow and becomes increasing complex, whereby MW management no longer relies on a few technical sequenced stages, but now involves a bulk of integrated and material-specific activities, with an organized network of intermediaries, logistic services, and recover systems.

Germany and the Netherlands are among the European leaders to have considered MW management as a public utility (respectively in 1975 and 1978), with municipalities not only entrusted for collection and disposal, but also legally obligated to deal with all waste conferred by households, charging no more than the actual cost of the service. In the same countries, soon followed by Denmark, a "prevention ladder" is implemented (Hafkamp, 2002)[4].

European Institutions, still in the form of the European Economic Community (EEC), gain a growing relevance in pacing the agenda of Member States, mainly with respect to environmental subjects. In the waste management sector, European policy priorities are aimed at reducing emissions, controlling waste shipments and exports as well as fighting illegal dumping. At the official establishment of the European Union, preventing waste production, and boosting recovery and reuse activities were added to the priorities.

From the 1980s European legislative authority concerning the waste issue as a whole ,including MW as well as special and hazardous waste, is steadily held by EU, with some restricted margins for State Members policies. EU outlines definitions and principles, sets technical norms and standards and provides suggestions for management schemes. As a result, in addition to national specifications, a common bottom line is established for all EU Countries.

In the early 1980s, standard MW management regime comes under pressures from two directions. Firstly,, a series of incidents involving soil and ground water pollution at landfill sites in Germany, the Netherlands, and Greece would rouse civil society apprehension. The same attitude associated with nuclear plants would then be transferred to waste disposal facilities. (Buclet *et al.*, 2002). Secondly, following the international trend of deregulation, the wave of privatisation in the public sector would significantly affect MW management.

In those years, a brand new and complex scenario would emerge; the general interest point of view, encompassed in the environmental and public health rationale is conjoint, if not overcome by, the "economic interest" approach (see *supra*) focusing on the trade and industry relevance of waste management. As a result, the MW sector would deeply change, both from the administrative responsibility level to the operational perspective. Different institutional levels become invested in the management of MW: from municipal (responsible for collection), to sub-regional (processing the collected waste), to regional (system planning), and finally to the National and European level (regulation). At the same time, new approaches in waste treatment would arise, simple dumping is flanked by incineration and recycling, and private companies enter the market to challenge public operators at any industrial stage of the waste chain.

In fact, until the 1990s in most industrialized countries, a clear separation between collection and waste management was maintained, with the public responsibility being assigned to municipalities through legal monopoly and organized in many different forms. Kemper and Quigley (1976) divided these forms into distinct classifications ranging from a full private to a full public forms: *Private* (leaving the provision of garbage collection to the market, imposing only minimal health regulations); *Franchise* (limiting the number of potential competing firms by franchising private collectors); *Regulated* (permitting legal monopoly but regulating the tariff to be charged and the minimal standards of service to be provided); *Contracted* (specifying the level of service and contracts, but delegating a private firm to provide the service); *Non-profit* (creating a collection agency independent from city government); *Municipal* (providing the service itself through a totally controlled public agency or through an instructed internal office).

This variety of classifications have been subsequently reduced through regulatory reforms within the last 30 years, with a massive shift of the boundaries between State-controlled and market activi-

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[4] Outlined as an *ante-litteram* Priority Ladder Principle (see *infra*), the rationale of the prevention ladder is that only inert material with soil-like properties or materials with nutrient values suitable for food chains are returned to the soil; all other materials must be recovered or burned.

ties, and stimulating a higher involvement of the private sector. Likewise, pure municipal provisions have been progressively excluded from the forms outlined in EU legislation, while different schemes of private law and Private-Public Partnership have emerged. Among them, the *In-house Company*, a limited company with 100% of its capital stock owned by one or more municipalities, and with a exclusive client base of its owners[5]; the *Multi-utility Company*, with majority of shares held by public sector entities (typically the same municipality that formerly owned the entire company, or a network of local neighbour authorities) with the remaining part of the shares sold on the stock market or held by a private partner.

Although all countries develop a planning system foreseen by legislation that is more or less implemented, the scope of the planning varies both between country to country and duration of time.

In Italy and Germany, for example, disposal was rigidly regulated within the frame of regional plans, which were obligated to address each waste flow to a suitable destination, as well as supervise disposal prices in order to avoid abuses, define and implement actions aimed at reduction or recycling. Within the last years, these countries have enlarged their assignments to the elicitation of management technologies, the selection of disposing sites, and to the setting of mandatory recycling targets. The planned facilities had to be created by local authorities or even by authorized private entities (Cima and Sbandati, 1999).

Conversely, in France and the United Kingdom the planning of activities are mostly concerned with supervision and ensuring that there is an overall adequate capacity in place, without interfering in investment decisions. In those countries, planning played a fundamental role in the infancy phases of the disposal industry, especially once the transition from landfill to modern solutions had to be coordinated. When industry further evolves, planning leaves space for operator-based integrated systems, restricted to the definition of targets, regulation and, if the case, provision of emergency solutions. This development is clearly correlated to the increase, both in the size and the scope of activity, of the role of the private sector.

In the 1990s, the private sector operated essentially as a subcontractor for collection services, mostly through Small-Medium Enterprises (SMEs) and social cooperatives (see Introduction), and as a supplier of disposal facilities (landfills and incineration plants). Even large international competitors play a role in local markets, often entering via acquisition of previously established SMEs, with different degrees of success and prominence according to the country[6].

In the second half of the 1990s, the growth of MW combined with the progressive land-scarcity faced by new landfill planners resulted to an increase in the price of disposal. As a consequence, many municipalities, forced by top-down planning as well as bottom-up initiative often recommended by municipally-owned companies, started to develop intensive recycling systems centred on street and kerbside recollection.

The achievement of reuse and recycling targets, turned out to be much more powerful and effective only after the responsibility shifted onto producers and retailers. This change rapidly boosted recycling records in all European countries to unprecedented figures reaching up to 30-50% of total waste flows.

The mechanism used to reach such performance was the implementation of the Extended Producer Responsibility (EPR) principle (See Section 1.3). The principle has been introduced in many national legislations, emulating Germany which at that time was the most advanced country with respect to this issue. EPR principle imposes all producers to provide a collection system for end-of-

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[5] Even if still allowed, in-house companies are not appreciated by EU regulator when operating in local utility markets; this particular structure is bound to be definitively ruled out and dismissed in next years.

[6] If in many places larger players are fully private, in Italy the only big private entity that seriously entered the market (the American *Waste Management International*) retired completely after unsuccessful performance still in the 1990s, placing blame on bureaucracy difficulties, structural delays and unfair competition from other public or semi-public operators.

the-cycle packaging with their product on the market, or pay a per unit fee for it – a *de facto* Pigouvian tax.

Another MW management novelty at the turn of the Millennium has been a comprehensive reform in many European countries, Italy included, based on the concept of *integrated* MW management.

This scheme entails a complete service arranged with the same company; a single and coordinated management system is established within a sub-regional district. An agreement among all involved local authorities leads to the definition of a common management system organizing collection, that sets targets for recycling and identifies final destinations and disposal solutions. The inter-municipal responsible entity would later adopt one of the legally authorized ways to operate the service, ranging from the creation of in-house companies to delegation. Within this framework, regional planning is now much more concerned with setting targets and enforcing regulations, rather than with directly managing facilities. Regional authorities maintain a residual responsibility as last resort solution to face disposal emergencies, especially where landfill capacity diminishes and alternative solutions are not already put into place.

Meanwhile, legislation concerning general or economic interest services has gradually forced municipalities to abandon public-law undertakings and choose the form of the private-law limited company, even for in-house provision. Publicly-owned companies, sometimes enlisted by private entities or by other municipal companies, are adopted almost universally as the preferred solution. In Italy and Germany, new firms are often the heirs of formerly existing utility service municipal entities. The most active among them are now aggressively proposing themselves as competitors outside their captive market of their original area, and engaging in partnerships with other local authorities separate from the parent company. This initiative takes often the form of mergers between companies that are already established and operating or the creation of new ones, to which assets previously run under direct management are underwritten in exchange for shares. In more sophisticated versions, the resulting companies are partially directed to the market through open sales and quotation of a minority share. Although a trend towards concentration at the regional level has been recognized (Dorigoni *et al.*, 2005), only a few of them have reached a size that qualify them as competitors on international market (among the others, Italian A2A, and French Suez and Veolia).

This development is mainly driven by energy sectors and sometimes, drags waste management and water into as well, although the latter activities are more frequently maintained in the original home market and not exported. Ownership is often shared with other municipalities or Administrations. Some mergers and acquisitions also include private and public undertakings, operating in the same area or having complementary assets (for instance mechanical sorting plants and landfills). As a natural consequence of these growth patterns involving multi-utility in MW management, vertical integration between the collection and disposal sectors have become increasingly more frequent, especially when landfill disposals are being substituted by incinerators.

Finally, the financial structure and charges for MW management services has undergone an evolution during the last years albeit far less revolutionary than expected by proponents. The traditional waste tax, formerly paid to local authorities, should to be assigned directly to operators on a cost-recovery base and referred to under private law; even when (or where) mandatory collection on the base of land property where its amount is calculated following indicators of presumptive waste production, with an incentive structure aimed at fostering recycling (see Section 1.5). Apart from what is expected, it must be pointed out that many municipalities still do not recover the full cost and pay the difference out of the general budget. Waste disposal price is an add-on to the total eligible cost that is transferred into the tariff. In case of cost discrepancy of the service due to unexpected variance in cost of inputs, such as fuel for collection trucks and disposal prices, they are recovered by setting a new fee in the following year. In any case, the issue is quite diversified throughout Europe, with different options ranging among market price, tax excises, yardstick competition tolls, and many others.

The new model entails a different relation with local community members, transformed in an active subject of the system, both due to its consumption choices, in favour of goods with low packaging, recyclable raw materials, and refilled/reused products, and because of its collaboration in sorting and managing waste starting from individual homes.

1.3 The European Union Regulation and Principles

Within the last 15 years, European Union MW management policy has been addressed to set a common ground between Member States. It is a policy oriented, on one side, to make local communities responsible for and aware of dealing with their-own generated waste and on the other side, to enforce progressively higher sustainable standards in the MW management chain.

The many European Directives issued through the 1990s and the first part of 2000s culminated into the European Parliament and Counsel Directive 2008/98/EC (emanated in November 2008, however enforced in December 2010), which sets priorities, norms and recycling targets with the general objective of "protecting environment and human health preventing or reducing negative impact of waste production".

With respect to the previous Directive 2006/12/CE, the new one provides a better specification of the fundamental notions of waste, recover, and disposal; strengthens waste prevention measures; introduces a whole life-cycle rationale for goods and materials. Finally, it calls for the attention to the reduction of environmental impact of waste production and management.

The Directive 2008/98/EC entails six principles for MW management, each of them corresponding to a set of general and specific norms, actions, requirements and obligations to be assumed by State Members.

The first is the *Priority Ladder Principle*, assessing that the right strategy in dealing with MW must follow a five-step hierarchical order, from prevention of waste generation to the residual choice of end-of-the-pipe disposal of materials no longer exploitable. Higher degrees of prevention means both a lower use of natural raw materials in producing goods, and a lower "consumption" of soil and environment in their disposal.

Following this rationale, the first and most important way to deal with the waste issue is to design goods in a way that reduces the use of raw materials, applies a lower packaging supply, and simplifies the process of separating its parts and components that could be reused, as well as taking into consideration the biodegradability of not further recoverable materials. As a first and residual alternative to waste reduction, the Priority principle claims for the reuse of a refitted commodity or as a second hand good to extend its utilization, or – and it is just the lower step of the ladder – the recovery of parts and components of it as a raw material of other goods to be produced or assembled. Since those three top "steps" of the hierarchy ladder identify the options giving best responses in terms of MW management, they must be supported by National waste policies. Directive 2008/98/EC imposes State Members to establish within 2015 a waste collection system at least for materials such as paper, metals, plastic and glass, and to reach the target of reusing and recovering at least 50% (calculated in weight units) of these kinds of waste by the year 2020. While trying to reach these goals, and to implement a progressively effective waste minimization policy, including the final objective of a zero-waste strategy, two further waste treatment techniques are considered: the energy recovery from incineration of waste materials that are non-recoverable, an option that implies the establishment of plants that require high intensity of capital, and the disposal in a licensed landfill. Although the latter is currently the most exploited treatment technique used in many European countries, it is expected to disappear in next years.

In spite of a renowned misrepresentation of it, the Priority (or Hierarchy) Principle does not assert that there exist different waste treatment techniques, ranked from most ecologically friendly to least ecologically friendly. On the contrary, it claims that in the mid-long run, the global European waste management policy should progress, abandoning the steps at the bottom and choosing the ones on the top.

The second and the third principles are the *Proximity Principle* (PP) and *Self Sufficiency Principle* (SSP), often mentioned jointly. They claim that each Member State should establish an integrated network of municipal waste treatment facilities in order to ensure a self sufficiency disposal and recover capacity at both the European Union and the national level. However, the practical implementation of these two conjoint principles have led to a complicated regulation of waste transfer, partially contrasting with the EU policy pillar of free circulation of goods throughout Europe. In order to fit with PP/SSP, is common practice for each Member State to implement a planning scheme that designs the compulsory territorial area (usually constructed on a sub-regional size) where to treat and dispose MW generated in any single place.

The rationale of PP/SSP is to impose each community to take control and responsibility of the challenge of disposing the waste they produce themselves in order to avoid the transfer of dangerous materials throughout Europe and to avoid the creation of "dustbin spots", specialized in hosting waste from other parts of Europe or from the rest of the world. It is worth noticing that the same carefulness is not devoted to Special Waste (SW), i.e. industrial and hazardous waste, that can be send in any licensed disposal centre in the world despite of its higher environmental unsafeness[7].

The fourth principle is the *Polluter Payer Principle*, which was actually introduced by the OECD in the 1970s, pivotal to the whole EU environmental policy through the 1992 Treaty of the European Union, and eventually adapted to the issue of waste by 2008/98/EC Directive (Buclet *et al.*, 2002). According to this principle, MW management costs must be charged to the same actors responsible for their generation, considering even the related external costs. The way to enact the principle in practice is through the right combination of tariffs and Pigouvian taxes. With regard to the waste issue, the Polluter Payer Principle is the root of another European environmental rule, the *Extended Producer Responsibility (EPR) Principle*, which claims that all actors along the goods production and retail chains are responsible for the final destination of them. This implies therefore that they should be involved in the complete life-cycle of their products "from cradle to grave" or, once applied to the MW management issue, that each industry must guarantee the achievement of reuse-recover targets, and of proper disposal of last materials. Besides some fields of application ruled by EU (packaging, electric and electronic devices, wooden pallets, industrial oil, cells and batteries), each Member State enjoys a huge autonomy in implementing the principle in other specific industries, and in organizing the modalities in order to take responsibility of it. These modalities would include the acceptance of returned empties and their disposal, the financial responsibility of disposing (through a tax or a fee), or even informing product consumers on the reuse/recycling possibilities for the good. Due to the EPR Principle, many Recovering Consortia have been established by Industrial Associations throughout Europe (see *infra*).

The fifth principle is the *Precautionary and Hazard Minimization*. This fifth principle is the basis of the complex and rigid nature of the authorization regime which all treatment facilities and their subsequent activities must undergo, including high technological and emission standards imposed on waste facilities, such as incinerators. The latter are subjected to more rigid standards than similar or higher polluting plants.

Finally, the application of the *Subsidiary Principle*, a general, yet very important principle in the Communitarian regulation body, to waste issue claims that most of operational initiative and responsibility in MW management must be concentrated into local authorities (municipalities and provinces), with monitoring and enforcement assigned to higher administrative (regional and national) levels.

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[7] It must be added that Directive 2008/98/EC relaxes the stringency of PP/SSP with respect to the previous Directive 2006/12/EC. In the regime of Directive 2008/98/EC, it is not compulsory to be equipped with the whole scale of treatment facilities, when explicated by planning documents , to address waste to plants and facilities sited outside the community area. As a matter of fact, the former draconian regime was the main reason for a condition of permanent emergency. Since most time landfills or incineration facilities suffered from capacity constraint and where close to exhaustion, waste collection was interrupted and the waste issue became a public security matter, to be undertaken by some National Authority.

In the wishful thinking of European Institutions, Directive 2008/98/CE and the principles it entails are the instruments to be used in order to facility the viability of the decoupling of economic growth from waste production; one of the main objectives of future sustainable development in Europe.

1.4 Trends in EU MW Industry

1.4.1 Waste Management trends in Europe

The combination of EU regulation with the illustrated ultra-decennial evolution generates a European MW industry that shows the following trends.

The waste production in EU-27 in 2010 was 503 kilograms per-capita, ranging from 298 kg per capita in Estonia to 718 kg per-capita in Denmark.

MW treatment modalities in 2010 involved 486 million tons (97% of the total waste production). End-of-the-pipe solutions still prevail (60%), even if they have definitely decreasing since 2001, when they concerned 73% of the whole treated material.

In particular, the total quota of MW landfilled in 2010 was equal to 37% (in 2001 it was 56%, -41 million tons); incinerated MW passed from 17% to 23% (+15 million tons), while recovered percentage increased from 27% to 40% (+29 million tons).

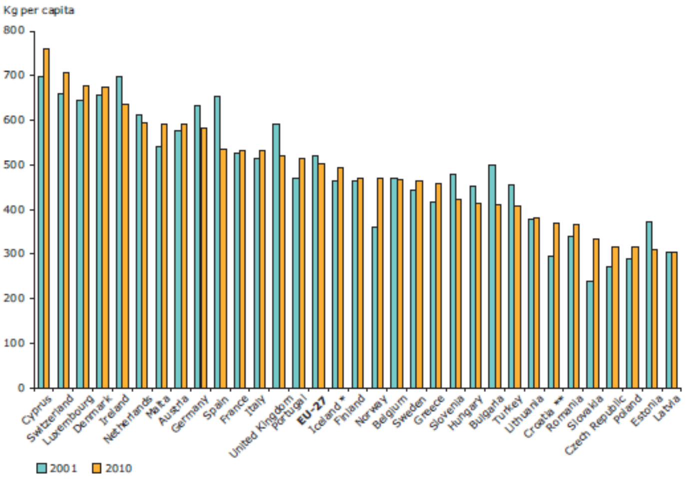

Fig. 1.4.1: Per-capita municipal waste in EU and associated countries, Years 2001 and 2010 (Source: EEA, 2013)

Fig. 1.4.2: MW separate collection quotas in EU and associated countries, Years 2001 and 2010 (Source: EEA, 2013)

Treatment methods deeply differ according to country. The Netherlands, Denmark and Austria have substantially reduced to nil landfilled MW, Denmark shifted to incineration; Romania (99% of generated MW), Bulgaria (94%), Malta (92%), Latvia and Lithuania (both 88%) are still strongly landfill-oriented.

Apart from Denmark (54%), incineration is a major option for Sweden (51%), Belgium (42%), Luxembourg and The Netherlands (38%), Germany (37%), France and Austria (35%). Austria exhibits the highest percentage of separate collection (63%), followed by Germany (62%), Belgium (58%) and the Netherlands (51%), a performance directly related with the higher fractions of recycling (63% for Germany, 62% for Austria, 61% in The Netherlands, and 57% in Belgium).

In conclusion, from these figures we able to obtain insight in some well known dynamics in the waste management issue. On one hand, there indeed exists a link between economic development and per-capita MW produced in a country and on the other hand, that the best economic performance are correlated to the exploitation and exploration for alternate treatment solutions to landfill disposal (Mazzanti and Zoboli, 2009).

1.4.2 A Focus on Italy

With regard to the MW management issue through the general European picture, Italy ranks at a medium-low position. In 2010, Italy generated 32 million tons of MW (26 million tons in 1996 and approximately 13 million tons in 1975). In addition to the growth in goods production driven by increased economic well-being, the three-fold increase of MW within last 30 years has been mainly the result of the expansion of goods packaging.

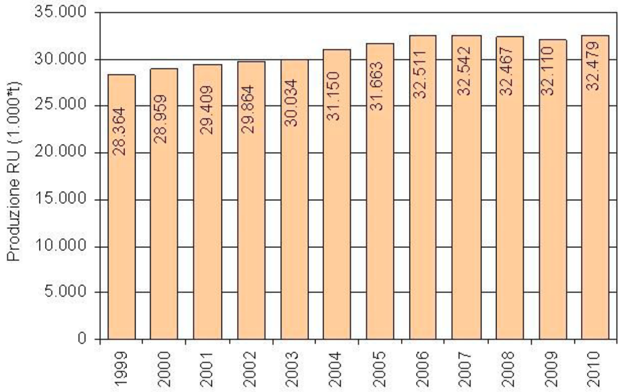

Fig. 1.4.3: MW trends in Italy, Years 1999-2010 (ISPRA, 2012)

In 2010, the production of MW was equal to 535 kilograms per-capita, although a better performance in comparison to the 2006 peak (552 kg per-capita), it was still higher than 10 years prior (516 kg per-capita). The regional scenario of MW is quite scattering: ranging from 413 kg per-capita in Basilicata (a small rural Southern Region) to 677 kg in Emilia-Romagna (one of the most developed Regions in Italy).

Ninety four percent of the entire Italian MW is subjected to treatment, mostly with end-of-the-pipe solutions: landfill is at 48% and incineration at 17%, while separate collection reaches just 35%. It is a performance below the European average, the EU objectives (recycling at 50% of the total amount of MW within 2020), also unfitting is the National threshold (45% of selected collection). On the contrary, they have attested to an evident high jump in National policies with respect to figures reported in 1996, and also in 2001 (respectively 90% and 68% of MW landfilled).

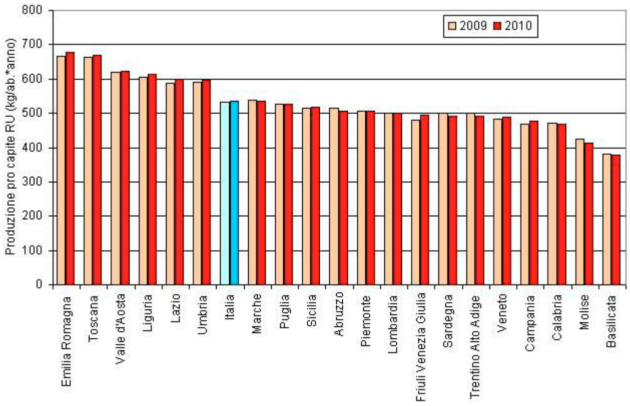

Fig. 1.4.4: Per-capita MW in Italian Regions, Years 2009 and 2010 (ISPRA, 2012)

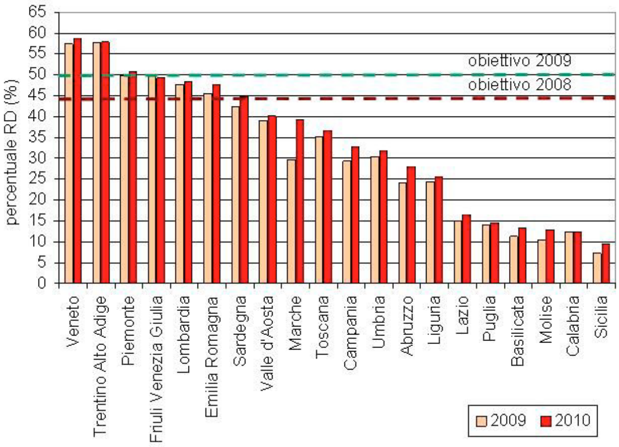

Fig. 1.4.5: Regional Municipal Waste selected collection in Italian Regions, Years 2009 and 2010 (ISPRA, 2012)

A notable divergence among Italian Regions is evident also on the basis of treatment modalities: landfill has become a residual option in Lombardy (8%), also due to an extensive use of incineration and energy recovery, but it is still the principle option used in Sicily (93% of treated MW). At the same time, just seven Regions out of 20 have reached the target of 45% in separate collection (Piedmont, Lombardy, Trentino Alto Adige, Veneto, Friuli Venezia Giulia, Emilia-Romagna and Sardinia). The standing is headed by Veneto (58%), and closed by Sicily (7%).

1.5 Market Design and Operation

Even though MW management has an environmental impact lower than many other less-regulated industrial activities, the normative framework for it is very restrictive, addressed to build up legal monopolies (or strictly regulated oligopolies) in the key segments of the industry.

1.5.1 The Market Structure

We can start depicting the MW industry as a two-segmented market, with an upstream sector of garbage collection and a downstream sector of disposal.

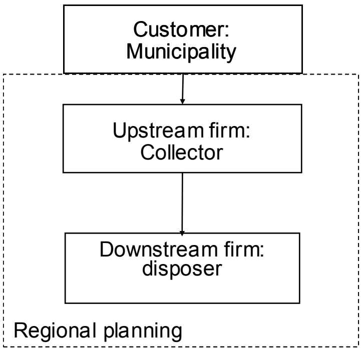

Fig. 1.5.1: Standard representation of MW management market with two segments

In addition, we can consider a third activity, aimed at improving reuse and recycling of raw materials. The existence of this modality affects both the upstream segment that must be organized in a way that allows separate collection, and the downstream one, since separate collection reduces flow of materials addressed to final disposal (landfilling or incineration). The separate collection option calls for the identification of new downstream operators, namely buyers of the recyclable materials.

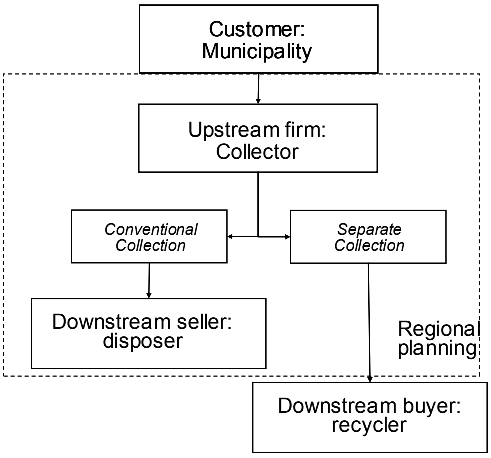

Fig. 1.5.2: Representation of MW management market with separate collection and recycling

In the current scenario, local authorities have the legal obligation of providing collection systems, and the corresponding right to impose a local tax or fee aimed at cost recovery. Although municipalities are allowed to choose their preferred way to fulfil this responsibility, they must follow the regulations, guidelines and master plans enforced by the EU, in addition to national and regional administrations which outline the minimum targets to be achieved and other quality and environmental standards to be met.

Companies operating under this regime, normally enjoy a legal monopoly delegated by the Municipality, motivated with the presence of economies of scale and cost sub-addictiveness.

The entrusted operator becomes legally responsible for the waste they collect, and has to dispose of it according to the prescriptions of regional plans. Those prescriptions include the facilities where to address primary waste flows. Waste that remains from treatment activities, all materials originating from it, as well as materials that have been collected separately, remain under the responsibility of the collection operator, who must ensure a proper destination for it[8].

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[8] The treatment and disposal regime is quite different for Special Waste (SW), since it is based on the legal responsibility of waste owners to dispose of them in an authorized way, namely running their own treatment and disposal phases or entrusting them to specialized operators. Companies providing these services operate on a fairly competitive national – if not international - market, even if subjected to an authorization system and an EU legislation foreseeing classification criteria, duties, and technical prescriptions. Municipalities can oblige certain categories of SW producers to join the collective service and pay for the corresponding tax. All remaining waste from treatment of the primary waste flows, both

Since the beginning of 1980s, the planning of waste disposal in Europe has been assigned to the administrative regional level[9].

Disposal segment in theory is heavily regulated by regional plans; in practice, it is left to the initiative of waste disposal companies, often in-house companies or public controlled multi-utilities, however increasingly evolving towards private status and behaviour. When both collectors and disposers are companies owned or at least controlled by public bodies, a sort of "political market" takes place, with prices agreed between the two entities. The disposal market, has been progressively entered by private operators, both SMEs (mainly in the sub-segment of landfills) and large multinational companies, in the capital intensive sector of incineration plants[10]. As a consequence, throughout Europe it is possible to find situations of hard price regulation, and other where price identification is left to demand and supply dynamics. Not surprisingly, the latter is one of the major drivers to separate and kerbside collection schemes implementation.

Recycling segment has been an important driver in the implementation of the Extended Producer Responsibility (EPR) Principle (see Section 1.3), enforcing the establishment of national responsible bodies, often controlled by industry and producers' associations, intermediating between waste generators and re-users.

Throughout the 1990s, EPR was enforced in Europe, initially with packaging materials (glass and plastics), that represent the main component of MW, followed by many other types of materials in the next decades. According to experts, the principle – that is put into effect through the establishment of a set of special "production chain consortia" implemented by Producer Responsibility Organizations (PRO)[11] - ratifies the end of the exclusive right of the Municipality on MW (see Section 1.2), and the birth of a parallel system[12].

While being a solution for the internalization of environmental externalities and the reduction of transaction costs related to market clearing and information on the availability of second hand materials, these bodies acquired strong market power exploitable either against municipalities, blocking or reducing the separate collection system, or against manufacturers, by generating discrimination in the internal market. As a matter of fact, the system is implemented as a legal monopoly, such as the previously mentioned Italian CONAI, or as a *de facto* monopoly, like DSD (*Duale System Deutschland*) in Germany or Eco-Emballages in France, where the retail sector is accustomed to reject products from manufacturers that do not comply with the membership: a strong incentive to join the PRO. On the other hand, EPR enforces the responsibility of industry as a whole in achieving recycling targets through a collective effort by all member companies.

MW and SW, is legally assigned to the SW category, forcing the firm who run the treatment facility to find a proper destination for it on the market (typically second hand materials users). However, there is clear evidence that in most cases this kind of treatment (mainly a mechanical sorting) has not produced recyclables, but rather materials that need to be landfilled or burned in dedicated plants. Therefore the main outcome of this treatment is that, legally, MW is transformed into SW, and the MW management company has more freedom to search for disposal solutions in other regions, since the SW market is not compelled to PP/SSP.

[9] From EU Directive 2008/98, any EU Member state must provide a Waste Management National Plan, containing a state-of-the-art of waste production and management in the country, a predictable evolution of both trends, and a setting of targets and modalities for reuse, recycling, and disposal. All National plans must be associated to a waste prevention programme, equally provided with targets and methods to reduce the waste production at its source.

[10] Example of multinationals or huge conglomerates in the European disposal sector are French Veolia and Suez, German Remondis, British Biffa. An interesting case is the Italian company, Pirelli Ambiente, which was established to put in practice solutions for the disposal of tires (Pirelli is one of the most important tyres producers in the world) and become an integrated operator active in the whole chain of both MW management and SWM.

[11] Generally speaking, a new consortium is established for each material to be recovered (glass, plastics, cardboard, electrics and electronics, wood, etc.). In many Countries, a large consortium gathers and represents all single production chain consortia. In Italy, this role is carried out by *Consorzio Nazionale Imballaggi* (CONAI).

[12] The new system was initially launched in Germany in 1990. It is suggestive that the name given was "Duales System", meaning a brand new MW management system parallel to the traditional one.

This results in typical free-rider problem as companies are left free to decide whether or not to join the system. These experiences lead to the conclusion that intermediation results in a bottleneck effect, and that the compulsory solution can be functional in the infant stage of the industry, but it is hardly justifiable after the industry has reached some maturity. In fact, some countries have recently ended with the legal monopoly of compulsory syndicates and favour the development of certified marketplaces for trading waste of any origin; the objective is to bypass the intermediation of producers' associations and allow waste owners to find easier alternative recycling opportunities.

1.5.2 The Market Operation

Going back to MW management organization, in all segments regulation is quite heavy on quality aspects (recycling targets, emissions, technical standards for facilities, etc.), however very weak on economic issues, limited to the phase of tendering in the framework of competition *for* the market. In addition, the introduction of a series of normative principles by EU aimed at harmonising national regimes seems to go in the opposite direction of a pro-competitive regulation.

The concept of competition is rooted on one hand in the intuition of Demsetz (1968), according to which services that are natural monopolies or entailing some characters of general interest (See Section 1.1) can be provided by private firms entrusted by Public Authorities through competitive tendering. On the other hand, it relays on the notion of contestability (Baumol *et al.*, 1982), stating that market power does not depend on cost structure per se, and it is challengeable by new entrants, that can take over the market and substitute the incumbent in the whole market or in some part of it; in this sense, even industries that are natural monopolies can actually be subjected to competitive pro-efficiency pressure.

Working on the tender design, public authority can reproduce a perfectly contestable market, provided that there is enough competition among the bidders. Sappington and Stiglitz (1987) have identified the conditions to be fulfilled in order to make it possible: absence of transactions costs in the bidding process; completeness of contracts; equal ex-ante information on technology, even when not complete; and finally, a high number of participants and a low incentive to collusion. These conditions are very difficult to fulfil, in general and in particular to MW management. A trade off among some of them could be identified (Massarutto, 2002): for instance, in order to increase the degree of completeness of contracts, these should be released for short periods; but if the tender is repeated, it is probable that the incumbent will gain a substantial information advantage. Moreover, shorter periods require that a solution is found for those investments whose repayment schedule is longer than the contract (Crocker and Masten, 1996).

Tendering is sometimes mandatory even when in-house solutions are chosen (e. g. in the UK), while in other countries (such as Italy) Municipalities are obliged to tender only when they wish to involve external parties, an obligation introduced only recently in response to EU pressures and claims. This situation affected in particular Public-Private Partnerships, since the European Court of Justice repeatedly has denied legitimacy to the direct entrustment of MW management contracts to already established companies, on the basis that Public-Private Partnerships should be created ad hoc for each specific transaction and after a competitive tender for selecting private partners.

With respect to tendering, two basic schemes can be identified. In the first one, collection and disposal authorities hold separate management agreements, either in-house or outsourced. This solution implies that the disposal authority actually must decide which disposal solutions to adopt, playing a more active role in the strategic decisions concerning the organization of the service. The second scheme, involves a single tender to entrust the whole integrated service of collection plus disposal.

The last scheme is particularly appreciated by incumbents and by more stronger firms, interested in protecting themselves against the contracting risks; however, besides significantly reducing the number of potential competitors (Crocker, 1995), experiments have shown very poor results, suggesting that tenders are not very suitable for integrated service (Massarutto, 2005).

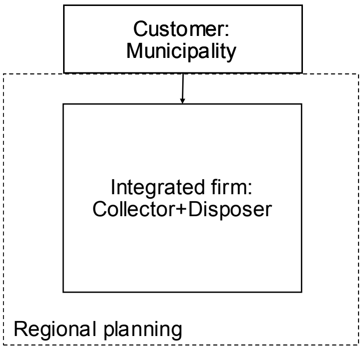

Fig. 1.5.3: A representation of MW management market with vertical integration of collection and disposal firms

Since the 1990s, EU directives have imposed to shift the payment system from a tax to a toll directly related to the provided quantity of service, exactly the same as gas, water and electricity. In many European countries the directives have been accepted, implementing a method based upon the weighing of garbage, both in dedicated platform (where people can voluntary bring in the garbage, having in return a discount on the set value of the waste tax), or in "smart" street dumpsters, equipped with scales that transmits to a computerized system the exact weight of the allotted garbage. Other less advanced, but equally effective systems, call for the substitution of waste taxes and tolls with the direct selling (by the Municipality or by the entrusted multi-utility or waste company) of household garbage bins and sacks, the only acceptable containers allowed for the waste collection.

In addition to the direct tax/toll revenue, Municipalities and entrusted companies are paid by the mentioned production chain consortia. In Italy this is roughly 10% of the total expense for the MW management, and by direct second hand materials buyers (mainly glass and paper mills). In the recycling market, industry pays on the bases of the differential cost calculated on a national average. Since this differential is a function of both local conditions for separate collection (organizing a kerbside recollection in historical downtowns or in a mountain village is far different and more expensive than in medium-size urban centres) and cost of final disposal, the incentive effect is very different: the incentive is strong in the most congested regions whereas it is much weaker where landfills are still available. This is also a reason for the actual difference between recycling records in countries like Italy, where it has reached averages of 25-30% and has peaked to 60-70% in some areas in the North, while virtually zero percent in many other areas, mostly in Southern regions of the country (see Section 1.4)[13].

1.5.3 (Another) Focus on Italy

In Italy, National Decree no. 22 of 2007 introduced the integrated management for MW. Instead of different segments, a single organization is created by the Regions and given the responsibility to design an optimal territorial district at a sub-regional level that is fully able to manage the entire MW cycle while fulfilling its objective to reduce the environmental impact of waste. The enforcement of the Decree deeply transformed the MW industry, even if introducing different solutions according to the where they have been implemented. In regions such as Lombardy and Emilia-Romagna, huge multiservice companies controlled by public authorities have prevailed. They are the "modern" version of the old and are no longer admitted as Municipal companies involved in the provision of many utility services such as water, gas and electricity, in addition to MW management. These companies are able to manage the entire MW chain, from collection to disposal, and often are the owners of landfills and incineration plants, and maintain relations with firms and op-

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[13] The rewarding system for SW is totally different, regarding 75% of the total waste production in Europe. As a matter of fact, this segment has always operated in a market regime, as any other good or service. The only duty to accomplish is to deliver the SW to an official licensed operator, registered in the National Ministry of Environment lists.

erators interested in recovered materials[14]. In many cases, these companies entrust some specific functions along the *filiére*, both specialized and capital intensive (like selection and waste treatment), or labour intensive and less profitable (like kerbside collection) to other operators, a practice that creates a market space even for SMEs, non-profit entities or social cooperatives.

The model varies in other Italian Regions, mainly the North-Eastern ones, where Municipalities establish and control new MW management companies that take advantage of specialized firms.

In both cases, the MW management chain is extremely branched out, with many operators carrying out specific and diversified activities (disposal, treatment, transportation, storage, plant construction, organization of support activities), requiring multiple competences and different investment abilities.

A branched chain may also be the result of the many alternatives that respond to an integrated MW management arrangement. Until a few years ago, the entire system was based on street collection with a single dumpster, which at the same time was a modality still unknown just thirty years ago. The second phase of selection involved a limited type of materials (scrap metals, glass) with the main percentage of collected MW considered for landfill.

With integrated MW management and selected collection, different modalities become implemented; proper kerbside collection, that calls for the complete vanishing of dumpsters on the streets and for home collection for unsorted waste; soft and hard multi-material collection, the first type of collection aimed at separating plastic, aluminium and other metals, the second collection taking into account glass materials; mixed solutions, where kerbside collection for some materials is added to street collection for some others. The real difference is noted by the organization of treatment and recovery system downstream of the collection phase: the main objective is the energy recovery through incinerator plants, the pressure to differentiation is weaker; incinerators and landfills are rare or next to capacity exhaustion, separate collection is preferred, until the dawn of the “zero waste” objective, which according to many experts and opinion leaders has a long ways to go but , is nevertheless not an impossible option of no waste conferred to last resort facilities.

Due to the latest transformations, currently in Italy MW management is committed mainly to public body-owned companies (45%, in reality providing service to 60% of the population), and to private firms (34% and 30% of population). Public-owned companies typically are fully integrated in the waste chain (being responsible for MW collection and running disposal facilities), while private ones are entrusted for specific services. This scenario is similar in the other EU countries, with more or less room for private operators according to traditions and general features of the local industry: it is higher in Germany and the UK where they are accustomed to the presence of private firms in utility markets, whereas it is rarer in France, where the “National champions” policy – i.e. the support to huge capital intensive and financially strong groups, strictly related with Government strategies - affects even the waste industry.

Finally, we focus on the compensation of the MW management service. Being an activity under the exclusive right of the Municipality, payment traditionally took the form of a tax collection owed by inhabitants to the local authority (in Italy, it was ushered in 1941) to cover the city cleaning service. The calculation of the tax was associated to family size, estimated based on the size of the dwelling (the rationale being that in a bigger house is easier to find a bigger family, hence producing a larger amount of garbage).

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[14] In the last years, some of those multi-utilities have begun to manage even second hand and “flea” markets, with the rationale of climbing the steps and occupy all the possible positions in the MW ladder: from disposal, energy recover, and recycling to reuse (see Section 1.3).

1.6 The Competition Issue in MW Industry

1.6.1 MW management and SWM: similar problems, different regulatory frameworks

In the collection market of MW, all European countries have adopted a model based on compulsory public services organized as legal monopolies, while the removal of SW in Europe is purely competitive. The difference between these very similar markets lays in two main arguments affecting MW, but not SW.

On one hand, it is a matter of economies of scale and density, hindering competition *in* the market for MW management. In the US were this has been most notable, the very few occasions in which households are left free to choose their waste operators, empirical evidence has shown support to the thesis that collective management of MW allows for significant cost reduction (Dubin and Navarro, 1988, Kinneman and Fullerton, 1999). Moreover, empirical studies conducted in Europe demonstrate that some scale economies can be achieved for up to 200,000 and 300,000 inhabitants (Antonioli *et al.*, 2000; Biagi and Massarutto, 2002), whereas there is some evidence of diseconomies for larger urban areas due to the congestion issue (Ascari *et al.*, 1992).

On the other hand, the joint action of PP and SSP – still applied to the sole MW management market – gives a substantial market power to owners of disposal facilities, which should be either strongly regulated by public planning, for example assuring the same access conditions to disposal sites to all operators, or overcome by vertical integration between collectors and disposers.

In the EU, the combination of all the imposed principles, in particular of PP and SSP, has led to the establishment of a strict sub-regional market for MW management, a situation with no correspondence in other good or service markets throughout the EU. This can imply a matter of competition in the MW management sector.

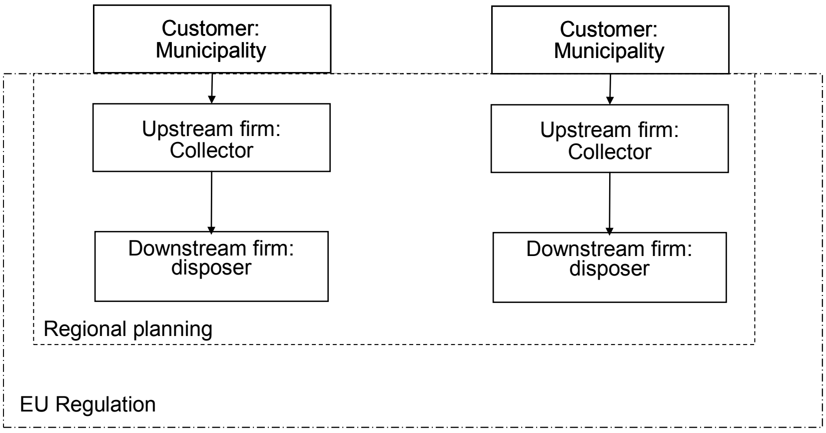

Fig. 1.6.1: A representation of MW management market with the application of PP/SSP

Potential competition restriction is accepted by EU regulators to prevent the risk of waste migration and pollution haven towards European countries or regions with low-standards

Brusco *et al.* (1995) provided a convincing demonstration of the appropriateness of these principles by arguing that institutional development in different local contexts - in particular the ability of public bodies to effectively control waste producers and enforce regulations - is also a function of the time required for putting more highly developed and sophisticated management systems into action. Since "waste emergency" affected urban areas and more developed regions first, namely during the last 1980s, while other neighbouring regions were able to rely on more traditional management systems, the explosion of disposal prices in the former areas was not corresponded by an increase in the latter. As a consequence, there was a permanent temptation to transform the neighbouring areas into some kind of urban dustbins (Massarutto, 2005)[15].

A second important reason justifying restrictions to waste trade is the existence of asymmetric regulations, so that PP and SSP act as standards' harmonization tools (Buclet *et al.*, 2002) among European regions with different environmental attitude and considerations. Nonetheless, the strength of this argument is somewhat reduced from many years (Bertossi *et al.*, 2002), even taking into account the EU Enlargement process: rules are not only more greatly harmonised throughout Europe, but they are also far stricter than environmental regulations in other sectors. Air pollution thresholds for incinerators, for example, are significantly more severe than those applied to any other plant, including energy or steel production. The handling of waste could therefore be considered as a normal industrial activity, making way for the trade of waste disposal services among areas. Enforcement capability is still unbalanced, but nevertheless it is increasingly more difficult to set up facilities that do not conform to minimum quality requirements even in the traditional waste bin regions, such as some Mediterranean or Eastern Europe countries.

A third proposed argument concerns the need to make local communities aware of their responsibilities. Because waste management is such an unwelcome activity, each community is tempted to free-ride, in the expectation that the solution will be shifted somewhere else. The PP/SSP has strongly discouraged this tendency to "beggar thy neighbours" and created the premises for the acceptance of new facilities *in loco*. Social opposition is surely a critical issue in the MW management industry, since it is related to cultural, symbolic and ideological factors that go far beyond the actual environmental impact of facilities (Dente *et al.*, 1998). In this light, the PP/SSP could be seen as an institutional guarantee that facilities will serve the needs of the community and not transform it into someone else's dumping place (Fischer and Petschow, 2002). Even if this were true in principle, it does not necessarily mean that after having shared the benefits with the local community, part of the capacity could not be re-allocated on the market in order to optimize technological choices. At least those operators that have been able to install facilities after coming up against social opposition could be given more freedom to operate in this way; institutional guarantees such as those provided by environmental certification might help in achieving the consensus (Massarutto, 2003).

A fourth reason affects the need for a strict supervision of waste handling, due to the permanent risk of improper behaviour by waste holders. While the accurate handling of waste, in compliance with environmental laws, causes no more pollution than many other industrial activities, externalities arising from illegal dumping are tremendously high. Since waste is a concretely existing material possessing negative value, there is a permanent temptation to dump it illegally, a practice more difficult to control under a free-trade system. (Fischer and Petschow, 2002). If empirical evidence undoubtedly supports this thesis - itis common knowledge that illegal waste trade is one of the most successful criminal business activities throughout the world - it is reasonable to assume that the highest risks concern SW and especially hazardous waste, while public entities entrusted of MW are less keen to engage in similar illicit activities. It would be therefore expectable that both PP/SSP and planning activities would give greater emphasis to this kind of waste, rather than to MSW. On the contrary, business, hazardous and industrial waste producers are far more free to choose the supplier of disposal services they wish, this is theoretically true for all producers all around the world.

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[15] The Italian case in this sense is enlightening: during the 1990s. While the developed regions in the North were facing a shortage in disposal spaces and a consequent price rise, a substantial part of their waste was sent to the South, with plenty of room to host "northern" garbage, but still lacking an appropriately environmental regulation, monitoring and enforcement system. The final result of this trend nowadays is well known, resumed in the definition of "Terra dei fuochi" (D'Alisa *et al.*, 2010; D'Alisa and Armiero, 2012).

1.6.2 The future of MW industry

The evolution for the MW industry opens to some interesting issues on the best regulatory framework to be adopted in the future.

The first one concerns the same vertical structure that the industry is progressively assuming. Because of it, the MW management sector is growingly dominated by multi-utilities and medium-large companies operating at the regional scale, having the necessary size, professional capabilities, financial solvency, technical expertise, reputation and capacity to organize and govern transactions with more specialized operators along the value chain. Regardless if the companies are fully and genuinely private or have originated from the transformation of public-owned companies they are able to share sunk capital investments with local public bodies, while activities involving a significant presence on the territory, and placed at the bottom of the value chain, are subcontracted to local SMEs and cooperatives. An innovative pattern of division of labour can be postulated, with local (public) actors having a competitive advantage in activities requiring sunk costs or where having deep roots in the territory and a reputation of stewardship and trustworthiness to local exigencies is a prerequisite of success; in addition to the location of facilities. All other industrial tasks will instead undergo a further market consolidation, both involving the increase in the market share of large players and the development of specialized enterprises for the different activities, from equipment to intermediation, from research to the development of innovative recycling solutions.

In this framework, a second question arises on the best available regulatory solutions to be adopted in the emerging vertically integrated and (at least partially) privatized legal monopoly for collection and disposal. The recommended solutions, both by the OECD (2000) and the EU, fundamentally based on competition for the market, do not seem the most appropriate, since competitive tendering is not easily practicable at the integrated service stage; even if tenders actually occurs, they cannot be based on simple performance parameters, and require careful specification of both quality performance and post-award renegotiation. Barriers to incumbent replacement in the next bids are high, and, in fact, the only way to prevent monopolization of the market is to contract single activities out, instead of integrated management. This requires in turn a public sector able to perform this task effectively. The trend in the market is clearly in the opposite direction: if this is the case, innovative regimes based on yardstick competition, price regulations, environmental and quality certification would be more suitable.

The third issue is strictly related to the previous one, and concerns the difficult and conflicting relations of this line of development with the emerging regulatory patterns at the European level. The EU started a policy in this field that substantially limits the degree of autonomy left to public powers in the choice of management solutions. The main concern seems to be the restriction to the possibility that public-owned undertakings become market competitors, exploiting advantages and privileges obtained on the home market in order to subsidize expansion to others geographical markets and sectors. To this purpose, public authorities are allowed to avoid competitive tendering only when the operator fits the very stringent definition of in-house provision (European Commission, 2004). Public-Private Partnerships should be intended as alternative ways for ensuring the fulfilment of a particular public service obligation and not as a way to create autonomous enterprises. Finally, public service obligations that justify the institution of a legal monopoly should be spelled out in detail and compensated on a strict direct cost base. In fact, it seems quite evident that many of the actual players in the MW management market are in some way deriving from already established local utilities. In many cases Public-Private Partnerships are the result of complex and sophisticated aggregations of incumbents, rather than being mere substitutes for delegation and direct management. The dynamic process of consolidation is still in course especially in countries like Italy and Germany, where the tradition of locally owned public enterprises has stronger roots.

The fourth issue concerns the emerging regime and its unclear potential outcomes on the equilibria characterizing other market segments such as those concerning SW, which is still one of the less known and regulated sectors of the economy (Massarutto, 2005). As long as the local markets are dominated by a business-oriented incumbent, holding legal or *de facto* monopoly over MW management, its capacity to successfully compete in the other waste markets becomes evident. Operating as a monopolist in the MW management allows a substantial market advantage, especially when there is exceeding capacity in treating MW which can be sold freely on the open market of SW. Landfilling of ultimate waste disposal offers a further opportunity, since facilities that are authorized for this purpose are normally the equally licensed for SW.

1.6.3 Increasing competition in the MW industry: positive effects and tangible risks

If waste authorities are capable of ensuring valid disposal solutions, the unbundling of collection and disposal segments can proceed quite efficiently. On the contrary, when disposal planning is inefficient or ineffective, integration should be achieved directly by operators, otherwise control of disposal will raise barriers to competition in favour of incumbents (Massarutto, 2002). If both the disposal and recycling markets were efficient and competitive, each waste owner would decide from an economic perspective on how much to recycle and how much (and where) to landfill or incinerate; the disposal and recycling segments would reach a local equilibrium in which the marginal cost of both would be equal. In this framework, disposal and recycling could be considered as side-competitors.

However, this competition is affected by significant market imperfections. When disposal is performed as an independent service forced to supply adequate capacity to meet demand, all waste collected in a certain area, if not recycled, will be disposed of in these facilities under the same conditions. A different solution applies if collection operators assume direct responsibility over disposal and create their own plants, or engage in long-term arrangements with disposal operators (via shareholding partnerships, purchase of bulk disposal capacity in the facility, flat tariffs, and so on). Both solutions however involve positive and negative aspects. In the first case, the separation between markets according to different segments allows competitive schemes to arise in the collection market: the separation between disposal and recycling allows side-competition to occur; since collectors' disposal cost is quantity-related, they will have the incentive to boost recycling as much as possible, especially if the cost of recycling is transferred onto product prices via EPR systems. On the other hand, economic sustainability of the disposal business is challenged. In order to meet their service obligations, disposal operators will have to invest in treatment capacity in any case, but they will receive no guarantee that this capacity will actually be used. Evidence can be found from Germany and the Netherlands, where over-capacity of disposal facilities is documented, confirms this risk (Fischer and Petschow, 2000; Kalders and Hafkamp, 2000).

The presence of vertical integration makes business more viable: planning of infrastructure will be easier since the same decisional head chooses how much waste to dispose of and how much capacity to put in place. However, as maintained by literature on the issue (Motta, 2004; Rey and Vergé, 2004), this could happen to the detriment of competition. Vertically-integrated systems are well-known devices of monopolization and, in MW management, they are not nearly as easy to liberalize, since – as we have previously pointed out - they are unsuitable for tenders. Moreover, there is also less incentive to engage in recycling efforts once investment has been made in sunk disposal infrastructure.

An important issue concerns the organization of the recycling market and the role of EPR. A potentially relevant advantage implied by EPR is the creation of an alternative system operating in competition with the ordinary undifferentiated system. As long as the responsible entities are provided with adequate incentives, this side competition would be beneficial, either because it helps to achieve higher recycling rates (with positive effects on the environmental issue), or because it represents an external constraint on the market power of landfill owners. This is even more fundamental with respect to vertical integration, since incentives to recycle are lower in this case, mainly when the PP/SSP is rigidly imposed. Market-based solutions for the recycling sector are likely to perform better if vertical separation between collection and disposal provide collectors with enough incentives to recycle.

Another issue is the interpretation of PP/SSP, and the potential benefits arising from a more flexible application of them. At a deeper sight, it becomes evident that they act much more as a surrogate of environmental standards' harmonisation throughout Europe, rather than as a regulatory instrument with a *per se* rationale.

A relaxation of the principles, combined with a stricter application of quality standards as well as in European countries with a lower tradition in environmental issues, could yield a double dividend. On one hand, a better environmental performance could be achieved and from the economic point of view, a more efficient MW management market open to competition that does not require firm regulatory and planning efforts by European, national and regional institutions.

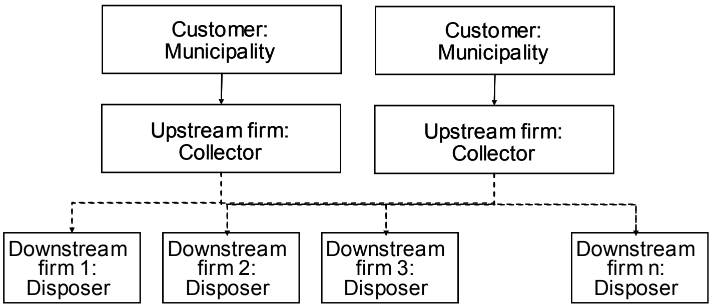

Fig. 1.6.2: Representation of MW management market with open competition in the disposal segment

Factors adverse to liberalization are nonetheless significant and should be considered carefully. Liberalization must overcome the difficulty in tracing a boundary, not only between private and public, but also between supply and demand sides, and the consequent need to consider the exact scope of activities that are open to competition. Many activities along the MW management value chain are well-suited to competition, provided that they take place in a context in which the organization of the value chain is already defined, and responsibilities on waste policy targets and related economic risks have been clearly allocated. However, if public authorities do not perform this task efficiently, competition could reveal less efficient.

A new open question regards the market power of the integrated company that is crucially related to demand elasticity. If the demand is inelastic, the monopolist can easily transfer costs on prices and be profitable at the expense of the exploitation of monopoly rents rather than cost-efficiency. Much the same occurs when price regulation is based on costs plus a fixed rate of return. For this reason, if free competition cannot be created, experts ask for pricing models based on automatic dynamic incentives to cost reduction, such as price-caps and profit-sharing mechanisms (Baron and Myerson, 1982; Armstrong *et al.*, 1994), or for cost benchmarking aimed at basing prices on the right costs and limit revenues to the coverage of these (Vickers and Yarrow, 1988).

Similar focus, though with a different methodological approach and sometimes different results, has been provided by institutional economics considering regulation as an "administered contract" between state and operating companies (Goldberg, 1976). Institutional economic literature has explored the sources of transaction costs of this kind and thus derived suggestions whether hierarchical (property, direct regulation) or contractual instruments should be preferred.

A visible obstacle indeed concerns social acceptance. While the need to control waste flows and guarantee safeguards to local communities is fundamental, this is not incompatible with liberalization, provided that operators of whatever the type of ownership, learn how to provide insurance on their reputation and reliability with respect to issues brought up by the communities that they serve. This reputation is probably easier to achieve if people perceive the MW management company as belonging to the same territory and community, but there are many instruments in order to obtain good results with respect to this challenge. First of all, general interest dimensions should be appropriately defined and enforced by regulators, specifying all components that the public authority considers as politically desirable (Sappington, 2005). Regulators should thus specify the required quality performance in terms of levels of service to be achieved and eventual penalties in case of failure. These are nonetheless assumed as something that can be unambiguously defined and transferred into a contract, provided that the regulator is able to identify the "true" social demand for service quality.

This way of defining quality is not necessarily the most appropriate one, especially for those activities that entail a significant degree of innovation or have less predetermined outcomes, requiring therefore higher degrees of freedom and autonomy in the individuation of quality (Picciotto and Campbell 2002). This is particularly the case when environmental utilities are concerned, and operators are obliged to respect quality regulations regarding the performance of their own facilities and services, but facing the same social rejection. For this reason, taking the example from industry with great social impact such as chemical and oil refining, it has been proposed to base quality regulation for disposal facilities on the compulsory acquisition of appropriate environmental certifications and labels (such as the EU EMAS and Ecolabel or the International Standard Organization 14001), rather than on the imposition of qualitative targets.

Private versus. public regulation has also been discussed in other regulatory fields, evolving towards the direction of self-government of communities. The application of game theory and transaction cost economics to public goods and externalities has revealed the conditions under which individuals may find cooperative solutions in order to overcome free riding problems and therefore achieve an optimal specification of public goods without state intervention (Olstrom, 1990; Oakland, 1991; Scotchmer, 2002; Faysse, 2005). Following this theoretical line, an "empowerment of the community" is advocated (Tietenberg and Wheeler, 2000); repeated transactions in the market, more simple interactions within communities sharing values, cultures and objectives have been demonstrated to be able to overcome market failures. While offering a strong argument against traditional state intervention, this approach has provided theoretical foundation to community- or stakeholder-based institutions.

In Europe, there is a solid tradition for similar institutions, often having a mixed nature with the involvement of some level of public administration, stakeholders and the public; sometimes on a purely voluntary and private bases, or with some public status. They are particularly lively at the local level and play a fundamental role in the provision of local services (Massarutto, 2005). Incentives for these kinds of solutions can emerge from many different sources, ranging from reputation and signalling strategies to stakeholders' pressure, from the threat of State intervention to economic instruments (Porter and van der Linde, 1995). The diffusion of voluntary devices such as ISO procedures, corporate codes, technical and performance standards of professional associations is now widespread in all developed countries (Carraro and Leveque, 1999; Croci, 2005).

1.7 Evolutions and Open Questions

At the end of this description the atypical nature of MW management is now notably evident. As mentioned, can be described following the EU taxonomy as a General Interest Service, claiming for strict regulation and control by public authority, however it requires an extent of technical skills and investments that selects progressively strong industrial subjects such as huge international firms, and multi-utilities, mostly in the integrate scheme of management and in the disposal segment. Contrary to other public utilities, it deals with a good perceived by households as a bad, and whose market value is low, except in times of emergency, when its real nature seems to impose.

The MW management market can be considered divided into two segments (actually in three segments when considering separate collection) with totally different added values, labour intensity and technologies, but intimately linked in an upstream-downstream relationship.

In addition, due to the requested skills of operators, it is quite difficult to justify the exclusion of MW management from Economic Interest Services, and not support a wider opening of the market to private companies and to a broad competitive dynamics.

At the moment, the General Interest issue seems to still prevail over the Economic issue in the minds of Regulators. At the EU level, there is of a kind of essential facility status that has been set to disposal units as well as compelling through PP/SSP a local destination to collected MW. Likewise, at the National level, preserving a public exclusive right on the collection segment through transforming a former in-house company in a Public-Private Partnership controlled by a public body. In a similar design, a strong planning effort by public authorities is obliged for different reasons: in the upstream market, because of sub-additive cost, and density economies and in the downstream market, to prevent disposal operators to exert market power, squeezing profits of upstream collectors.

MW management industry however, seems prone to gain efficiency and effectiveness in terms of total social welfare. PP/SSP can be considered both a warranty against pollution haven, and an important tool to force local communities to take care of their own waste, limiting the generation of externalities, but they contribute to build up market power of downstream firms, reducing in this way the competition and the social advantages of it. In order to avoid the exploitation of this market power, there are different types of strategies, none of which are immune to some level of costs. The strategies include: putting into practice substantial regulatory and control efforts by public bodies; vertical integration by firms, with the risks of monopolization of the market and regulator capture it involves; boosting separate collection, which could mean an advantage for the system as a whole, but is more costly for the collector firm and – also for individual citizens. Finally, the unfair practice of running an ineffective selection treatment on MW, and re-labelling as SW in order to dispose of it outside the district.

A completely new scenario could be drawn with the removal or at least the relaxation of PP/SSP, opening the disposal segment to competition, whose efficient market size would be defined by incidence of transportation costs.

Liberalization is not automatically synonymous with efficiency, mostly in public utility service markets. With special focus on services of general interest, the EC survey (European Commission, 2004) on the impact of liberalization, it has been criticized for being overly optimistic with the results achieved. Since the emerging positive evaluation was not actually in line with the empirical evidence, and not until a more complex definition of performance based on social welfare is adopted, the picture will remain blurry on this issue. In another survey, Florio (2004) shows that British privatizations in the utility sectors has hardly generated overall efficiency improvements nor has had apparent reductions in service quality. Rather, the main effect has been a distributive one (shifting the cost burden from public budget –taxpayer- to users) and a decrease of labour costs (due to staff reductions), compensated by an increase in capital costs. Nevertheless, it is important to understand the role of regulatory framework in MW management social welfare and if modifying it is a viable and fruitful option.

In conclusion, even though there are some justification for the setting up of legal monopolies on MW management, alternative solutions could be explored, Among those include: encouraging non-public collective institutions (neighbourhoods, communities, common property boards, NGOs,) to be eligible customers at an intermediate level between municipalities and individual households, and allowing waste collectors more freedom to decide on the final destination. Otherwise, keeping the current organization could mean maintaining different kinds of ineffectiveness and, what is more problematic, restricting competition in the MW management market.

This topic is further explored with the model introduced in Chapter 3.

Chapter 2:
Literature Review

In this chapter we define a theoretical framework for the study of municipal waste. In order to do so, we focus on three main topics developed throughout this report.

Firstly, (Section 2.1), we consider the literature on regulated markets that establish a relevant basis for the theoretical model illustrated in Chapter 3 and evaluated in Chapter 4. As we will see, regulated markets experienced a substantial boost at the beginning of the 1990s, concurrently with the strong wave of privatization of public utility industries, mainly in Europe, and a treatise in following years related with competition policy issues.

Secondly (Section 2.2), we analyze the state of the art of economic literature on waste management, the general field of our work, with themes that range over behavioural studies on individuals' attitude to separate collection, market structure of waste management services, incentives to waste policy targets, and social costs of disposal.

Thirdly (Section 2.3), we address the issue of innovation in economics, which will represent the theoretical support to Chapter 5.

Finally, some final remarks (Section 2.4) summarize the key results in the perspective of the issues developed throughout the following chapters.

2.1 Literature on Regulated Markets

The large liberalization process that occurred in the US and Europe over last decades has given rise to a huge branch of studies dealing with market competition and regulation, in the perspective of the request for efficiency in public utilities, natural monopolies and, more generally, currently or formerly public-owned companies.

The problem of competition in public utilities is often confined to the phase of tendering for the required services. It is the so called competition *for the market* (Demsetz, 1968), claiming that industries characterized by a natural monopoly or that entail elements of general interest ought to be managed by private firms, with the right to operate entrusted by the Government via competitive tendering based on the well-known notion of contestability (Baumol *et al.*, 1982). Nonetheless, the issue of competition *in the market*, dealing with the degree of openness of public utility industry, is more neglected, and the same principles introduced by EU and aimed at harmonising national regimes, seem to go in the opposite direction of a pro-competitive regulation. With respect to this topic, the main works are from Porter and van der Linde (1995), Crocker and Masten (1996), and Massarutto (2007).

As pointed out by Crew and Kleindorfer (2012), in last 30 years regulatory economics has undergone major developments. The sudden rise of attention on this issue goes back to 1982, when the US Justice Department filed an antitrust suit against AT&T that ended with the divesture of AT&T-owned local telephone companies (the so-called "baby bells") in 1984. The interest was reinforced in the 1980s with the extensive privatization of utilities in the UK, Europe and elsewhere in the world.

From a scientific literature perspective, the foundation of regulatory economics can be seen in the seminal work of Averch and Johnson (1962) and publication of Kahn (1971). During this period, the discipline acknowledged the foundation of The Bell Journal of Economics and Management Science (1970), a product of AT&T's Bell Labs' economics group. In 1984, after the AT&T divesture, the journal was acquired by RAND Corporation, leaving the orientation to regulatory issues to become a leading journal in industrial organization.

Nonetheless, the visibility of regulated industries and the growing interest for this topic made regulatory economics one the most important sub-sector of Industrial Organization and provided the basis for subsequent researches (Crew and Kleindorfer, 2012).

A prominent role in this process had been played by the aforementioned theory of contestable markets (Baumol *et al.*, 1982), whose analysis on the nature and structure of costs, multiproduct pricing and cross subsidy continues to have a major impact on the discipline. In 1989, the hiatus originating from the interruption of the publication of The Bell Journal is replaced with the founding of the Journal of Regulatory Economics, providing a new place for discussing the field of regulation.

In reviewing the last developments in the theory of regulation, Armstrong *et al.* (2007) illustrate the four main subjects of optimal regulation of monopoly, design of practical regulatory policies, regulation in presence of competition forces at work, and regulation of vertically-integrated industries.

In the line of Baron and Myerson (1981), Lewis and Sappington (1989), and Laffont and Tirole (1986, 1993), the first topic is analysed in terms of optimal regulation of a monopoly producer that provides private information about key elements of the market. This strand of literature focuses on the incentive designs to be implemented to induce a monopoly supplier of regulated services to act in the best interest of the consumer, modelling the relevancy of incentive contracts and revelation mechanisms such as auctions in procurement and regulation. As a matter of fact, to limit the rent, a regulated firm could extract from its higher information, a regulator who could propose a properly designed selection of options to the firm, inducing the monopolist to employ its private knowledge to realize Pareto gains. Those options induce outcomes that differ from the ones that a regulator would implement in the case of symmetrical information. Nonetheless, they are a device to limit monopolist's use of his higher information endowment when the regulator's commitment powers are restricted.

Optimal regulation literature, most notably identified with Laffont and Tirole (1993), has been criticized for the recourse to the assumption of common knowledge, a postulation that does not reflect the severity of the information problem that regulators face in real the world. This omission prevents the theory to represent a useful contribution to policymakers, and it is responsible for little impact on the practice of regulatory economics (Crew and Kleindorfer, 2012). Although formal models on optimal regulatory policy can provide useful insights about the properties of regulatory policies, these models seldom capture the full richness of the settings in which actual regulatory policies are implemented. For this reasons, another branch of the discipline deals with the desirable properties of regulatory policies with pragmatic direction. These kinds of studies focus on the extent of pricing flexibility granted to the regulated firm, the manner in which regulatory policy is implemented and revised over time, the linking of regulated prices to real costs, and the degree of discretion allowed to regulators in formulating policy.

One of the main contributions to this approach is given by Armstrong, Cowan and Vickers' work on British regulatory reforms (Armstrong *et al.*, 1994). Having a robust point of reference in the Littlechild's reports on price cap regulation for telecommunications and water industries in the UK (Littlechild, 1983, 1986), the authors sketch an analytical framework of regulatory reform and apply it to utility markets. Their starting point is the availability of effective and undistorted competition in industries with both naturally monopolistic and potentially competitive activities. They argue that liberalized utility industries, characterized by "a number of interacting economic, political, and technological factors" at work, provide fertile ground for a rich variety of monopolistic and anti-competitive practices, so that those markets claim for a regulatory reform, rather than deregulation.

Armstrong *et al.* (1994) search for the common elements of four utility industries (telecommunication, gas, electricity and water supply), highlighting that all of them combine (i) naturally monopolistic activities such as transmission networks, and (ii) potentially competitive activities, such as the provision of the services over the network. They remark that public policies dealing with this kind of industries have to consider the vertical integration issue (could the natural monopolistic firm be allowed to operate even in the potentially competitive segment?); the liberalization issue (is the potentially competitive segment open to entry?); the market structure issue (can the assets of a monopolist operating in the potentially competitive segment be horizontally broken up once liberalization is enforced? Are monopolists nationwide or geographically separated?); the price structure issues (on the forms that regulate consumer price of the service and access prices to the monopolistic service), and finally with non-price issues (regulation of quality and compliance with environmental requirements).

After applying their analysis to the four mentioned utility industries in the United Kingdom, they conclude that more than 10 years after the enforcement of the liberalization process, effective competition had not yet arisen, and both competition and regulatory policies for the utility industries had to be reinforced. The main problems have been identified in the persistence of vertically integrated operators that do not enjoy equal conditions with other players in competitive activities, and in the partially related persistence of incumbent's benefits.

Other contributions in this line of research remark on the fact that the regulator's ability to achieve their objectives is related to the number of instruments at their disposal (Armstrong and Sappington, 2006). This observation is relevant even in the treatment of the third subject of theory of regulation, namely the use of potential or actual competition to discipline the regulated firm and increase social welfare.

The analysis of those benefits deals with many subjects: the design of yardstick competition (Demski and Sappington, 1984; Sheifler, 1985; Cremer and McLean, 1985), under which a monopoly supplier in one district is disciplined by comparing its activities to the activities of monopolists that operate in others; the competition for the market, from the mentioned pioneering work of Demsetz on monopoly franchising, to the contribution of Che (1993) and Branco (1997) on the ability to force franchised monopolists to supply higher quality services and the role of contestability as a regulatory device, in the framework of competition in the market (from the seminal and mentioned work of Baumol *et al.*, 1982, to new contributions by Armstrong *et al.*, 2007).

The discussion on competition and regulation highlights that actual or potential competition can be exploited to reduce the rent of a monopolist, but the same competition can considerably complicate the design of regulatory policy, for instance undermining the effect of pricing structures of competitors on the franchised operator, who must recover fixed costs, or even on the pursuing of distributional objectives by the regulator.

Finally, there exist relevant regulatory policy issues related to vertical integrated industries, the provision of essential inputs from an integrated firm to rivals in downstream segments of the industry, and the permission to operate in the competitive retail market for a monopolist producer.

The main theoretical contributions come from Rey and Tirole (1986, 2007), Besanko and Perry (1993), Vickers (1995), Khun and Vives (1999), Scherer and Ross (1990), Rey and Vergé (2004), while the practical implication of vertical integration is deeply considered in the already cited Armstrong *et al.* (1994)[16].

A key element in this field is given by access price and retail price setting by the regulator, and by the necessity of regulatory oversight of the interconnection agreements between facilities-based network operators, even after substantial competition has already been developed.

A final consideration must be given to those industries that are more frequently associated to regulatory issues. At the inception of the discipline, the "champion" was telecommunications, once the1990s reforms and privatization wave swept across the World (and Europe) the relevance of electricity soon emerged. Since then, regulation continues to have a strong presence and involve-

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[16] For a deep treatment of vertical restraint and other devices of monopolization, see Motta (2004).

ment in the realm of public utilities (gas, water supply) as well as the environment, while other fields of interest such as postal, banking, insurance and financial services still persist in the agenda of theorist and policy makers.

2.2 Literature on Waste Economics and Management

As illustrated in Chapter 1, the last 30 years have witnessed the deep change of MW market from a low-added value and labour intensive service dominated by the collection segment, to a complex, multi-stage industrial activity focused on the post-collection phases of recycling and disposal. Since the 1970s, waste generation in industrialized economies has increased exponentially, adding growing pressure on the disposal system. Most common facilities (landfill sites) began to lack, while a mounting protest against any kind of polluting plant made it progressively more difficult to establish new incinerators, showcasing the unavoidable problem to the eyes of public opinion and policy makers.

As a consequence, in the 1980s and 1990s the subject of waste management subject made great strides into the world of economics broke through economics. A recent review by Kinnaman and Takeuchi (2014) offers a thorough insight on the most popular themes on the economic approach to MW management: they include behavioural studies on the attitude of individuals to separate collection; analysis of the market structure of the waste industry; waste trade; regulation on the industrial organization of MW services; application of monetary incentives and other economic instruments to promote waste policy targets.

We can classify the economics of MW in the two broad categories of theoretical and empirical studies, with a kind of *trait d'union* in-between given by the "Waste Kuznets Curve" (WKC) topic, deeply rooted in the theory of the Environmental Kuznets Curve (Selden and Song, 1994), but with a strong empirical emphasis.

The theoretical issues regard on one side the modelling of the MW market and, on the other, behavioural studies on agents at the community level.

Contribution to MW market focuses mainly on the optimal policy to be implemented in order to obtain the desired targets of recycling or MW reduction. Kinnaman and Fullerton (1999) review that issue, illustrating models that deal with taxes on original materials (Dinan, 1993; Palmer and Walls, 1994), subsides to recycling (Palmer and Walls, 1994), disposal fees (Palmer *et al.*, 1997), deposit-refund systems to correct for the external costs associated with garbage disposal (Fullerton and Kinnaman, 1995; Fullerton and Wu, 1998; Atri and Schellberg, 1995).

New contributions in this field analyse the impact of taxes (Davies and Doble, 2004), and compensation schemes (Jenkins *et al.*, 2004; Caplan *et al.*, 2006; De Paoli and Massarutto, 2007; Bucciol *et al.*, 2014), while in more recent years EPR-based policies gained significant attention (Shinkuma and Managi, 2013).

Another field of interest for the theory of MW management is given by waste trade and related environmental aspects, from pollution haven to ecological dumping. Ley *et al.* (2002) examine the inter-temporal allocation of MW produced by cities in the same country, to spatially distributed landfills and incinerators; Kellenberg (2012) develop a two country trade model with externalities associated with harmful waste generated from consumption; Shinkuma and Managi (2013) model an international waste trade case with environmental pollution; Sasao (2014) addresses the issue of waste shipment and trade restrictions.

Quite surprisingly, less attention has been reserved to the industrial organization of MW sector, in particular to the downstream segment of waste disposal. Wagner (2011) explores upon private versus social microeconomic decision-making at landfills level, clarifying how landfill inputs (in this case identified in monitoring effort, local natural resources, and engineered technology) are differentially selected by private owners and social planners; Massarutto (2015) remarks that, contrary to what happens with many utilities (electricity, telecommunications, transports and water supply), the organizational framework of waste disposal supply is quite neglected, and many relevant issues are still neglected such as the degree of competition in that segment; the most appropriate way to select operators of disposing; the risk of market power acquirement by private owner of facilities; the efficient setting of gate fees; the obligation to operate within a given area contemplated by SSP (see Chapter 1); the freedom to sell capacity at convenience for facilities.

Some studies demonstrate that the control of suitable disposal capacity represents a barrier to competition in the waste management sector as a whole, and MW collection could be easily opened to competition via auctions and tendering. This is feasible only when all collectors have the same right to access to disposal solutions at analogous conditions (Buclet and Godard, 2000; Massarutto, 2005). Risk of lock-in is also significant, due to the high sunk costs involved by disposal facilities, mostly when they are incinerators. However, the lock-in effect is more likely to occur when incineration has provided a satisfactory response to local needs, so as there is little or no pressure to change (Corvellec *et al.*, 2013). Moreover, even though regulatory economics postulates that the absence of competition would reduce the incentives to operate efficiently, especially when facilities are allowed to pass-through their full cost to customers, this topic is not frequently analyzed (Massarutto, 2015).

Finally, from the aforementioned seminal paper by Fullerton and Kinnaman (1995), to the Sugeta and Shinkuma (2014) study of the optimal recycling rate with respect to subsidization policies and to the degree of international trade of the final good, some consideration is given to the use of recycled materials as inputs in vertically related industries.

On the theoretical foundations of households behaviour in handling MW, Jenkins (1993) demonstrates that the recycling rate responds to disposal fees modifying the time that households spend in recycling activities; Morris and Holtausen (1994) consider the ease of recycling activities as a relevant issue in waste reduction. Recently, Cecere *et al.* (2014), and Ferrara and Missios (2012) built on this line of research a huge behavioural strand focused on NIMBY syndrome (for a review on NIMBY, see Bottero and Ferretti, 2011).

The contribution to empirical analysis of MW management in the last 20 years has been quite substantial.. The fields of applicability range from cost estimation for different management solutions, to the study of drivers of selection and recycling, measurement of waste trade as well as economic aspects of epidemiological studies and, in recent years, a new issue of crime economics related to waste management has emerged. .

With respect to cost estimation, Kaulard and Massarutto (1997) use cost-benefit analysis and engineering estimation methods to depict different MW management scenarios, demonstrating that integrated management (see Chapter 1) raises MW total costs if compared with a traditional MW chain based upon landfill disposal, but cost increase is more than compensated by the improvement of both environmental performance and occupation, in the "double dividend" framework (Tullock, 1967; Goodstein, 2003). Other works use cost-benefit analysis to evaluate socioeconomic effects of incinerator or mechanical biological treatment (Marchettini *et al.,* 2007).

In relation to the former, the measure of the "right" balance of recycling and end-of-the-pipe disposal, in the mark of integrated management, is the subject of a relevant strand of empirical literature in MW. Thorneloe *et al.* (2007) compare a set of alternative scenarios with varying degree of recycling and alternative options for the residual, finding the socially optimal rate of recycling in the range of 20%. Kinnaman and Takeushi (2014) use a sample of Japanese municipalities to show that the optimal rate of recycling is 10%, jumping to 36% when social costs are considered. Pearce (2005) compares the costs and benefits of landfill and recycling, concluding that, even accounting for full social costs, evidence is favourable to landfill until absolute scarcity of location for new facilities does not lead to substantial cost rising. Dijkgraaf and Vollebergh (2003) reach a similar conclusion for the Netherlands, criticizing on this basis the EU priority ranking of solutions, which privilege materials recovery in first place and waste-to-energy with respect to landfill.

Turning to the search for the drivers of MW generation and disposal, the calculation of direct and cross elasticity of prices and income is reviewed by Choe and Fraser (1998), who highlight the contributions by McFarland (1972), Wertz (1976), Efaw and Lanen (1979), Hong *et al.* (1993), Fullerton and Kinnaman (1996).

Socioeconomic factors that affect recycling rates and MW disposal are identified by the literature in unit pricing, disposal fee and per capita income (Jenkins, 1993; Medina, 1997; Sidique *et al.*, 2010; Saltzman *et al.*, 1993), including variables such as a household's degree of ecological consciousness and the amount of time required to sort the recyclables from waste. Curtis *et al.* (2009) use a panel data to identify the determinants of household waste generation and disposition in Ireland, finding that the average size of a household is negative for total waste production and positive for mixed waste quantity, but not statistically significant. Callan and Thomas (2006) find that household size and age are significant determinants of the demand for disposal service and education is a significant determinant of recycling. Oskamp *et al.* (1991), through interviewing a sample of randomly selected adults in a suburban city, find that the most important factors affecting people's involvement in kerbside recycling programs are demographic variables, attitudes and behavioural variables that pertain specifically to recycling.

A substantial selection of literature by Mazzanti *et al.* (2009, 2011, and 2012) find evidence on the significance of unit pricing, the physical features of an area, and the demand for landscape amenity for the final rate of MW selection implemented by a community.

A lower number of studies have dealt with the political influence on MW management (see Chapter 4): local government intervention can improve MW recycling through regulation, economic incentives and information programs, but policies are often driven by political orientation and election promises. Looking at the standard literature, Hage and Söderholm (2006) are among the first to analyze the role of the differing MW management policies of plastic packaging recycling in Sweden and the impact of environmental preferences. They find that a weight-based fee has a positive and statistically significant effect, even if it might have side-effects like incentive for illegal waste disposal. They also find that there is positive and statistically significant interaction between Green party support among households and the collection of plastic packaging, and a positive but not statistically significant representation of the Green party in the local government. Benito-López *et al.* (2011) evaluate the efficiency of street cleaning and MW collection services in Spanish municipalities, finding a positive correlation between it and being ruled by a progressive party. Bornstein and Lanz (2008) show that willingness to contribute to public environmental goods reflects pre-existing ideological orientations.

A growing strand of literature considers the existing relations between MW management and crime economics. The issue is particularly perceived in Italy, where illegal waste dumping has turned in one of the most profitable activities for different kinds of crime associations in the last decades. Starting from the theoretical contributions by Sullivan (1987) and Fullerton and Kinnaman (1995), prosecuted by Choe and Fraser (1998) and Shinkuma (2003), the empirical literature is still quite underdeveloped. Almer and Goeschl (2010) analyze the deterrence effect of sanctions for environmental crimes in 15 German states in the period 1995-2005. With respect to Italy, new works have been addressed by D'Alisa *et al.* (2010), D'Amato *et al.* (2011), D'Amato and Zoli (2012).

Finally, a last investigation area for MW, with both theoretical and empirical features, is related to the EKC argument. Studies on the evidence of a Waste Kuznets Curve (WKC) was carried out in the 1990s and in the first decade of 2000 by Beede and Bloom (1995), Cole *et al.* (1997), Andreoni and Levinson (2001), Johnstone and Labonne (2004). Strictly connected with WKC, more recent studies focus on delinking, i.e. on the real mismatching of economic growth with increase in waste production (EEA, 2009; Mazzanti *et al.*, 2009; Iafolla *et al.*, 2010; Nicolli and Mazzanti, 2011; D'Amato *et al.*, 2011; Mazzanti *et al.*, 2012). With regard to the EKC studies, those works show that even for MW, the evidence of a bell-shaped relation between waste generation and income or growth indicators is questionable.

2.3 Literature on Innovation and Technical Change

Technological and organizational change is defined as innovation when the introduced novelty entails increased efficiency.

Given that innovation has become the “industrial religion since the end of 20th century”[17], Economics of innovation has gained new prominence in the last decades.

At the dawn of the economic discipline, Adam Smith and David Ricardo focused on the technical change embedded in goods and on its influence on productivity, some topics that would have been rescued by neoclassical economics in more recent years. A different point of view on technical change was proposed by Marx, who emphasised the social dimension of innovation, to be seen as the result of relationships and conflicts among economical and social groups (Malerba, 2000a).

For many years, the same issue of economics of innovation has been associated to the figure and the studies of Joseph Schumpeter. Schumpeter is the first to provide a definition of innovation as the exploitation for economic purposes of a scientific or technical knowledge internal (through Research and Development activity, hereafter R&D) or external (through acquisition on the market) to the firm (Schumpeter, 1919). In the same study, Schumpeter offers a taxonomy of innovation, described as the introduction of a new good (product innovation), of a new production or sale method (process innovation), and of a new organization or market form (organizational innovation).

In his wide-spreading work, Schumpeter calls the attention on the discontinuous nature of innovation, with waves of disruptive technological change that sweep away old goods and industry that produces them (Schumpeter, 1935). At first, he identifies in the single entrepreneur and in its “animal spirit” the driving force of innovation, the agent able to move forward the technological frontier searching for market benefits. His later studies, he remarks the pre-eminence of big and monopolistic firms, exploiting economies of scale related to R&D investments, and the existence of “strategic” industries, characterized by a higher technological content and with positive spillovers on the whole economy of a country (Rosenberg, 1983).

The studies of Schumpeter have been seminal building blocks for Economics of Innovation, both of neoclassical and heterodox orientation. We can see the influence of Schumpeter on neoclassical theory in the accent on drastic innovation and in the substantial scepticism on the innovation aptitude of small-medium enterprise. At the same time, his emphasis on the innovative force of non-competitive market and on the uncertainty affecting the entrepreneur, incapable to grasp all the implications of the innovation he introduces, put Schumpeter in the mark of heterodox innovation frameworks, such as evolutionary and complexity theories.

In more recent years, neoclassical economics of innovation focuses on a set of fundamental issues, neglecting others such as the stress on process innovations and the consequent cut in production costs and price reduction, rather than on product innovation compatible with price differentiation; the attention for equilibrium conditions (optimal length of patents, firms winning a patent race and gaining the market), rather than for adjustment processes; the interpretation of innovation as the product of information accumulation and learning by doing, rather than as a new way to look at artifacts with a different perspective; the willing to increase market quotas and gain extra-profits as the driving force of innovation; the role of technical change and technological progress in Gross Domestic Product (GDP) growth.

Substantial neoclassical literature descends from the mentioned Schumpeter’s intuition on the relation between market structure and incentives to innovate. A new beginning, in this sense, is given by Arrow (1962a), who concentrates on process innovation reducing the unit cost of production entailed by different kinds of agent, namely a monopolist, an oligopolist and a social planner. The final outcome of this influential work is the so called “Arrow’s argument”: in both cases of drastic innovation (i.e. a technical change that produces higher profits for an outsider rather than for an incumbent) and of non-drastic innovation (conversely), the total benefit of innovation is increasing

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[17] The Economist, *Survey of Innovation in Industry*, 20th February 1999.

with the number of competitor and it is the highest for a social planner. The adducted reason is that the incentive to innovate is lower for the monopolist, that would end “replacing himself”, while an outsider or a competitor would replace the former incumbent (a situation labelled as “leapfrogging”) or at least increase its market share.

Starting from Arrow’s study, a new generation of models wondered on the results of non-cooperative and cooperative R&D activity. The first line of works is the so called “patent race” family of models, where innovators participate in a winner-takes-all competition to gain a leader position in both R&D and final product markets.

Relevant patent race models are provided by Loury (1979), Dasgupta and Stiglitz (1980), Lee and Wilde (1980), Gilbert and Newberry (1982), Reinganum (1982), Grossman and Shapiro (1987), Scotchmer and Green (1990), De Fraja (1993), Denicolò (2000), Stein (2008).

The first contributions share the same framework given by firms with symmetrical costs structure and expected benefits from innovation. Considering fixed upfront R&D costs, Loury (1979), and Dasgupta and Stiglitz (1980) show that the effort in R&D is lower when competition increases, but competitive equilibrium is affected by over-investment in R&D. The picture changes in Lee and Wilde (1980), where firms pay a variable cost that falls to zero when they cease to invest in R&D. In this case, the outcome is the opposite and R&D effort at equilibrium increases along with the number of agents operating in the market.

The assumption of symmetry is abandoned with the second group of patent race models, rooted in a game theory framework. Gilbert and Newberry (1982) introduce a sequential game with an incumbent leader and an outsider follower competing to reach a non-drastic innovation. The final result is that the incumbent wins the patent race (monopoly persistence), but an “efficiency effect” arises, i.e. consumers of the final product can exploit the benefits from innovation. Reinganum (1982) considers a simultaneous game with stochastic achievement of drastic innovation by incumbent and outsider; she obtains that incentive to innovate is higher for outsiders (leapfrogging), however, no benefit for consumers is generated, so that the final outcome is just the replacement of the former monopolist with a new one (replacement effect). Finally, in the same line of research, Denicolò (2000) considers a simultaneous game *à la* Reinganum (1982), with a non-drastic innovation *à la* Gilbert and Newberry (1982); showing that the effort in R&D is a strategic complement for both incumbent and outsider, and that the final results in terms of persistency of the incumbent or leapfrogging, and of replacement or efficiency effect are ambiguous *a priori*.

A different branch of studies, midway between non-cooperative and cooperative R&D, focuses on multi-stage research activity. Pioneered by Grossman and Shapiro (1987), this group of models consider the cases when intermediate technological knowledge is the input for the final achievement of sequential innovation, and the implementation of a weak patent regime leads to faster technical change. In this mark, Scotchmer and Green (1990) consider the role of disclosure, i.e. placing new findings in the public domain, as a prominent tool to spread the knowledge necessary to promote the diffusion of inventions. De Fraja (1993) shows that a firm might find it profitable to help the rival in achieving the innovation, if there are enough benefits from finishing “second” in the innovation race; Stein (2008) shows that a spontaneous collaboration will arise if firms have the opportunity to share their own progress repeatedly when facing multi-step sequential innovation (Blasco, 2012).

Cooperative R&D is debated by Katz and Shapiro (1985), Grossman and Shapiro (1986), D’Aspremont and Jacquemin (1988), Kamien *et al.* (1992), Leahy and Neary (1997), Salant and Shaffer (1998), Belderbos *et al.* (2004).

Katz and Shapiro (1985) focus on licensing agreements, i.e. the transfer of technology from an innovator to one or more licensee firms for a fixed-fee or royalty. They conclude that licensing can have important effects both on the development of innovations and on total surplus for society as a whole, but even that minor innovations are more likely to be licensed than major ones. Grossman and Shapiro (1986) apply to Research Joint-Venture (RJV), i.e. the creation of a new economic agent aimed at developing R&D activity and owned by at least two firms, to find out that RJV benefits are given by scale returns (economies of joint research), elimination of duplicate costs in R&D, spillovers from dissemination of results (ex-post dissemination), and capability in stimulating R&D investments (ex-ante incentives). Contributions by D'Aspremont and Jacquemin (1988), and by Kamien *et al.* (1992) belong to the so called "non-tournament literature". The two studies argue that R&D always leads to lower production costs, benefiting all firms of an economy. In particular, the latter model, analyzes the effects of RJV on welfare under Cournot and Bertrand competition, reaching the conclusion that in both cases a RJV cartel yields the highest per-firm profit. Generalizing D'Aspremont and Jacquemin (1988) results, Leahy and Neary (1997) find that when they do not act strategically, firms sharing a RJV agreement achieve higher levels of both R&D effort and final production. Salant and Shaffer (1998), show that RJV increases social welfare even in the case of lack of technological spillovers. Finally, a more recent contribution to cooperative R&D literature is given by Belderbos *et al.* (2004) in an empirical work on Dutch firms. They find that R&D collaboration with competitors and universities increases sales attributable to market novelties, while cooperation with suppliers and competitors leads to a growth of value added per employee.

Another typical neoclassical argument on innovation is the optimal design for intellectual property rights (IPR) reward and patent protection. The issue deals with both the rightful size of breadth and length shelter and with the comparison between prizes, patent protection, contests and other rewarding schemes as the best remuneration system for innovation.

On the first issue, a seminal contribution is given by Nordhaus (1969), who wonders on the existing relationship between duration of protection and social welfare, finding non conclusive arguments in favour of a length limitation. Incorporating even the breadth of protection, i.e. the allowed degree of "invention around the patent", Klemperer (1990), Gallini (1992), Denicolò (1996), Maurer and Scotchmer (2002) suggest that the best protection design for IPR and patent in terms of social welfare is based on a restricted breadth conjoint with a long length.

Several economic history contributions explore the efficiency of prizes as a reward method for innovations (Porter, 1994; Zuckerman, 2003), while other works focus on the comparison among different incentive mechanisms for innovation (Kremer, 1998; Foray, 2004; Scotchmer, 2004). Scotchmer (2004) argues that the best incentive scheme changes with respect to the considered research environment. In places where research ideas are scarce, patents seem to fit better, while public prizes could be the best solution whenever it is able to set up a rivalry among potential innovators, even though intellectual property is more effective in relating the reward with the social value of the innovation.

The last neoclassical topic we consider is on the contribution of innovation to GDP growth. With respect to this issue, the point of departure is undoubtedly the Total Factor Productivity model by Solow (1957), who introduces in economic literature the role of technological progress, giving birth to modern Growth Economics. Studying time series of US economy from 1909 to 1949 applying a Cobb-Douglas function to estimate the growth dynamics, Solow realizes that GDP is systematically and heavily under-rated when considering the National Account values for labour force and capital factor. Solow explains this residual value with the increase in productivity of inputs made possible by technological progress. In the line of Schumpeter (1919, 1935) and Kuznets (1930), he suggests that technical change, acting as a factor productivity multiplier, is the main driver of economic growth. In addition, in his model Solow stresses the parametric nature of growth, replicable in any economy throughout the world, destined to converge in the long-run to the same natural and common growth rate.

Albeit preserving the rationale and the technical set up of Solow's model, Arrow (1962b) claims that, rather than parametric, growth is fuelled by endogenous drivers that reflects the disparity existing among different national and economic systems. Following this intuition, the new paradigm of "endogenous growth" arose, with several studies emphasising alternately the main contribution of various factors to growth: human capital investment (Lucas, 1988), learning by doing that increase workers' skill and productivity (Grossman and Helpman, 1991), investment in R&D (Romer, 1990; Aghion and Howitt, 1992).

Focusing on the contributions more directly concerned in the role of R&D, Romer (1990) builds up a model where GDP growth relies on the increase in the availability of new capital goods, made possible by the investment in human capital in R&D sector. Aghion and Howitt (1992) propose a very technical model, where investment in R&D influences the availability of intermediate goods, regulated by a stochastic mechanism *à la* Poisson. The new intermediate good drives the older and less efficient out the industry, increasing the productivity of intermediate sector and – as a consequence – of the whole GDP.

Many assumptions of neoclassical economics of innovation are challenged by new paradigms that have arisen in last few decades and labelled as "heterodox approaches". Starting from the paramount point of refusing the alleged full rationality of economic agents (Simon, 1962), new theories disclaim the fact that most of innovations are incremental and cumulative, not disruptive, until a technological discontinuity appears; the fact that innovations are characterized by learning by using and they are historically and socially determined; finally, the fact that any innovation generates uncertainty in the agents' space and the main role of Public sector is to reduce that uncertainty.

The relevance of the historical pattern that leads to innovation has a launch in Nelson and Winter (1982) and a climax in David (1985).

Nelson and Winter's volume outlines a new evolutionary theory of the behaviour of firms operating in a market environment, with respect to economic change and innovation. Borrowing from biology the notion of natural selection, they highlight the importance of adjustment processes and the sequence of historical occurrences in market equilibria, following in their argument the line of many technical change scholars, who recognized the role of bounded rationality (Rosenberg, 1976; David, 1975; Mansfield *et al.*, 1977; Pavitt, 1971). From their work, a new family of "history friendly" models on industrial organization and innovation arose (Malerba, 2000a)

In one of the most famous works of the last years, Paul David (1985) introduces the well-known example of the diffusion of typewriting on QWERTY keyboard. He illustrates how a chain of almost accidental historical facts could create a rigid condition that blocks the system on a less effective solution difficult to be overcome.

In another influential work, Arthur (1989) labels these dynamics as "path dependency", that could end in a "lock-in" condition, i.e. a situation that, albeit improvable, stands unchanged for a long while when not irreversible. According to Arthur (1989), the reasons for path dependence could be the existence of sunk costs to be recovered, such as the learning costs depicted by David with QWERTY, or the existence of norms and habits difficult to overcome, or even the presence of network effects (Katz and Shapiro, 1985 and 1994; Economides, 1988).

Evolutionary economics is the inspiring theory of a new branch of studies in innovation. It is the so called National Innovation System (NIS), considered an empirical development of the former. In the US version, NIS investigates the role of formal institutions in supporting innovation (Nelson, 1992), while in the European version, the so called "Aalborg school", the focus is on how institutional framework (both formal and informal) and industrial organization affect the innovation attitude of a country (Lundvall, 1993)[18]. In a North (1990) perspective, the Aalborg version of SNI considers institutions as a set of habits, routines and norms regulating interactions among bounded rationality agents in a state of instability and uncertainty.

The same accent on uncertainty and the role of institutions to support agents affected by it, is well rooted in another heterodox approach; the innovation economics according to Complexity (or

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[18] The same emphasis on the empirical aspects is the base for another model of innovation of growing reputation: it is the "triple helix" approach, stating that innovation spreads out by the simultaneous action of firms, universities and institutions that – as the blades of a helix - change their position playing the role of counterparts, so that university support the birth of innovative start ups to fill a supply lack, firms contribute to design innovation policies and programmes, while institutions experiment new solutions in market burdened by uncertainty (Leydesdorff and Etzkowitz, 1998).

Chaos) theory. Developed by Santa Fe Institute scholars, Complexity thinking is a systemic and dynamic approach considering the outcome of the behaviour of each agent and of the system where the agent is embedded is intrinsically dynamic, and it can only be understood as the result of multiple interactions among agents operating in evolving structures (Antonelli, 2011a).

Complexity Economics relies on a set of assumptions: the relevance of agents' space of interactions (considered as a pure and non-interesting virtual perimeter by neoclassical theory), and of the hierarchical organization of interactive agents; the continuous adaptation of agents to external context, through evolution dynamics and learning processes; the incessant raise of new products, markets, technologies, behaviours creating niches in global and local systems; the existence of multiple equilibria and the implausibility of a global optimum to be achieved (Arthur *et al.*, 1997). The final scenario emerging from this assumption recovers the Marxian intuition of innovation as a social driven event.

Because of the coexistence of previous characters in many economic systems, standard empirical techniques such as econometric approaches are no longer applicable; they are replaced by computer simulations addressed to cover the whole set of relevant hypothesis and of the available adaptation trajectories (Rosser, 1999).

According to this approach, innovation is a property emergent when complexity is organized (Antonelli, 2011a). This intuition, joint with the perception of uncertainty as a central issue of the Complexity paradigm, suggests a fundamental role for institutions in implementing stabilization from erratic dynamics and coordination policies.

Lane and Maxfield (1997, 2005) identify three types of uncertainty, intrinsic to the transforming action of agents. They are: epistemological uncertainty, related to the real existence of the phenomenon (is a phenomenon true?); semantic uncertainty, related to the interpretation of the phenomenon by interacting agents (are we attaching the same meaning to the phenomenon?); finally, ontological uncertainty, related to the vision of the world and the categories to describe it (is my representation of the state of the world still plausible, after the evidence of the phenomenon?). The latter one is the most problematic, since innovation changes the state of the world and prevents agents to foresee the consequence of their own actions.

This means that innovation, besides of its positive potential, generates primarily an ontological instability that ought to be guided, and that guidance role is upon institutions. As a matter of fact, there are two main instruments to deal with ontological uncertainty according to the authors: the first ones are the "narratives", i.e. a cognitive process to give rationality to what is happening, to compare different points of view and to set medium- long-run objectives of change; the second one are the "scaffolds" (or "scaffolding structures"), i.e. institutions of various kinds (public administrations, research and support centres, universities, scientific reviews, employers associations, trade unions, accelerators and incubators) entrusted to mediate among agents and innovations, and to act as a point of reference in the natural condition of uncertainty generated by a changing environment. The role of scaffolds is to sustain and to strengthen network linkages, exploring new opportunities, circulating novelties, proposing new functions to products, addressing the stream of information and steering R&D activity.

Another distinctive construct of economic complexity of innovation and technological change is given by the notions of "artifact". Lane and Maxfield (1997) and Lane (2006, 2011) label an artifact as any man-made object able to embed technical or social change, or to achieve some particular attribution of functionality. The emergence of a new artifact generates a new uncertainty to be handled by agents in a system. As a consequence, they change their scale values, behaviours, and actions; many of them are driven out of equilibrium and react to achieve a new one in a complex setting. A higher degree of organization of complexity, usually related to the role played by institutions, allows converting the change in growth more easily. Conversely, both disruption (due to insufficient organization) or dissipation (due to rigid path-dependency) could arise.

The combination of the agents (firms, individuals, and institutions) organized around a set of evolving artifacts, and involved in recurrent interactions is labelled as "market system". It can be associated to a given artifact, for instance “the market system of printed book” (Bonifati, 2008), or to an industry, such as “the market system of Municipal Waste” (see Chapter 5).

Through interactions, agents commission, design, produce, trade, provide, use and maintain artifacts, generate new attribution of functionality and develop new artifacts to achieve the attributed functionality (Lane, 2006). All those actions are not driven by atomistic choices; rather they are socially determined, being the outcome of the social features of the system populated by agents and a cognitive act of innovation, obtained by the building of an agents/artifacts space that creates a new market system.

Other topics belonging to the complexity approach to innovation are the relation between technical change and knowledge (Antonelli, 2005) and – as for neoclassic theory - the contribution of technical change to economic development.

Saviotti (2011) provides a deep insight in the notion of knowledge and its features. Rooting in Informational Theory (Shannon and Weaver, 1949), he describes knowledge as a co-relational structure and as a retrieval or interpretation structure.

In the first sense, knowledge is the product of the mental association among observables detected in the external environment and different variables to represent and measure them. This association generates a theoretical framework where a reduced number of entities are the fundamental determinants of a large range of phenomena. On the other hand, knowledge is the outcome of an uninterrupted exchange between internal and external information, with internal knowledge (what is already known) determining the ability to learn external knowledge and to use existing information.

As a consequence of previous considerations, knowledge is represented as a network with the nodes given by concept and variables, and the links given by the joint-utilization of them (Saviotti, 2011). A common character of such a system is being “local”, i.e. not fully connected, since: (i) the creation of new nodes precede the creation of links between them and between them and the old ones; (ii) knowledge can provide co-relations only over a restricted number of variables at a time; (iii) knowledge can provide co-relations only over a limited range of values of variables; (iv) the probability of the holder of a given internal knowledge to learn some piece of external knowledge is inversely proportional to the distance between the two kinds of knowledge in the total observable space of knowledge.

Starting from this theoretical and definitional framework, Saviotti (2011) uses social network analysis to represent knowledge and innovation networks involving firms and organizations of the biotechnology industry. It allows to bring out a high degree of structural change in the sector, with new knowledge (i.e. molecular biology) and consequent technological classes emerge in substitution of older ones (namely traditional chemistry).

An interesting review in this field is provided by Cantner and Graf (2011), who emphasise the inter-disciplinary nature of innovation networks studies, a research area that has been inspired by contributions in the field of management (Powell *et al.*, 1996), sociology (Granovetter, 1973), economics (Nelson and Winter, 1982), and geography (Saxenian, 1994).

Following the line of the relevance of interaction in the study of innovation, in contrast with the attention to individual nodes, Consoli and Patrucco (2011) explore the relevance of innovation platform, i.e. systemic coalitions, hierarchically organized, for the coordination of distributed capabilities and knowledge processes with high degrees of complexity.

Finally, Bodas Freitas *et al.* (2011) investigate the different forms of governance of university-industry collaboration that allows the best performance of university as knowledge producer and provider for private sector.

With respect to the relation between innovation and development, complexity theory approach stands on the legacy of unbalanced growth and post-Keynesian school, and remarks the role of product, rather than process, innovation and of “mesonomic” architectures.

Robert and Yoguel (2011) acknowledge the influence of Myrdal (1957), Hirschman (1958), Prebisch (1959), and Kaldor (1972) as precursors of development factors related to macro-complexity, due to their emphasis on the relevance of economic structure, the existence of divergent dynamics between countries and regions reinforced by feedback effects, attention for disequilibrium conditions, and the role of institutional change. The authors merge this approach with emerging literature on micro-founded development (Amsden, 2004; Ocampo, 2005a, Cimoli and Porcile, 2009) to identify industrial policies as the main tool for the processes of creative destruction and structural change, fostering absorption and connectivity capacities.

The multi-dimension nature of innovation processes is stressed by Dopfer (1994, 2011). Paying a deep tribute to Metcalfe (1998) and evolutionary economics, he depicts economy as an evolving process where the rule trajectories (the meso elements of the economy) are embedded in a process structure (the macro element) and affects the behaviour of firms (the micro elements). Addressing the complexity of the environment, meso-economics provides a useful analytical platform for theoretical explorations of economic issues. Not coincidentally, a strand of literature with strong connection with knowledge and innovation studies points up the role of meso-institutions for local development (Nonaka and Takeuchi, 1995; Brusco, 1989; Arrighetti and Seravalli, 1999; Becattini and Rullani, 1993).

Finally, Frenken and Boschma (2011) consider economic development under the influence of complexity theory being characterized by a joint process of economic growth and qualitative change (Saviotti, 1996), uneven development across regions and countries (Boschma and Frenken, 2006), and driven by local agents such as firms and cities (Frenken and Boschma, 2007). In addition, they stress the relevance of product innovation in generating growth dynamics in firms and urban structures, allowing the integration of insights from Industrial Organization and Economic Geography in a single theory.

2.4 Final Remarks

Regulation, waste economics and innovation theory are the three disciplines that serve as theoretical framework for this work.

Our *excursus* in regulation theory (see Section 2.1) put in evidence the focus of this subject on many utility industries (typically telecommunication, electricity, gas and water supply). Presumably not perceived as a network industry, waste management has been totally ignored by regulation and competition studies. This is particularly puzzling, since waste industry in general and MW specifically seem to be characterized by all main subjects of the regulation issue highlighted by Armstrong and Sappington (2006): the optimal regulation of monopoly and former monopolies in a newly liberalized market; the design of practical regulatory policies; the commingling of regulated and competitive agents inside the same market; and, last but not least, the regulation of vertically-integrated industries, with actors operating on both upstream (Disposal) and downstream (Collection) segments, and circumstances where an agent plays as essential facility to others.

The issues of vertical integration and of the persistence of incumbent's benefits are remarked by Armstrong *et al.* (1994) among the main problems for competition in the four mentioned utility industries. We will see evidence from a case study that identifies the same challenges in MW in the Italian region of Lombardy (see Section 4.3.3).

Finally, we discovered that regulation studies applied to utility industries concentrate mainly on competition *for* the market, neglecting the issue of competition *in* the market, which will be the subject of the model developed in Chapter 3.

Turning to the second theoretical base of this work (waste economics, Section 2.2), we observe that most familiar themes encompass the separate collection, the empirical studies on drivers of recycling and the so called "Waste Kuznets Curve", and the waste trade issue, whereas less attention is dedicated to the industrial organization of the MW sector.

Finally, comparing mainstreaming and heterodox approaches, we highlighted pronounced differences in interpreting innovation and technical change (Section 2.3) While neoclassical economics of innovation is interested mainly in process innovations that allow cost reduction and price cut, patent protection, and equilibrium conditions, heterodox theories are more concerned in cumulative innovations that are historically and socially determined, out of equilibria conditions, and agents reaction to the uncertain framework generated by innovation.

Complexity theory, in particular, considers change intrinsic to a system characterized by the variety and creativity of their components, and by the degree of heterogeneity of operating agents. The actual directions of change are determined by the interaction between creative agents rooted in a well-defined space, exposed to endogenous events that alter expected conditions on products and factor markets, and external knowledge. Interaction between local action and external knowledge generates a complexity that could produce new knowledge and innovative effort by firms. Persistence, resilience and innovation forces interact, with characters of both path-dependency and development, the latter due to the degree of organized complexity of the system. In this sense, mesonomic institutions enable in a better way the dynamics of positive feedbacks and the successful recombinant generation of new knowledge (Antonelli, 2011a).

In Chapter 5, we will see that Complexity framework seems better suited than the Neoclassical approach to explain the spread of innovation in the MW industry.

Chapter 3:
A Model of Competition in the European Market of Municipal Waste

Municipal Waste (MW) is the waste generated by households. In Europe, local bodies at the municipal level are legally obliged to provide a collection system for municipal waste, following regulations and guidelines provided by communitarian directives, national laws, and regional plans.

In addition to setting the minimum targets to be reached and the environmental standards to be met, European Union (EU) claims that MW should be handled and disposed close proximity to the location where it is generated. The justification of this policy is rooted in the two pillars of Self-Sufficiency and of Proximity Principles (PP/SSP), and aims at preventing the creation of pollution havens in regions with low standards and making local communities aware of their environmental responsibilities (see Chapter 1).

In this exercise, we claim that the economic motivation for PP/SSP is that it is a mechanism to induce a sufficient level of separated collection and, as a consequence, a way to keep environmental externality at a tempered level. However, it is worth exploring if other instruments, such as the Pigovian tax or a compensation scheme could be more effective in reaching the same objective in terms of externalities, without renouncing the benefits of a more competitive environment.

The MW market exhibits different characteristics, according to the industry stage taken into consideration. Due to scale and density economies, the collection segment can be considered as a legal monopoly as its nature of public/merit good (i.e. a bad collection causes significant negative externalities to the local community) advocates for the implementation of a compulsory public service. The disposal segment should still operate in a competitive regime, but PP/SSP forces to find the disposing facility inside a defined district, allowing the disposal agents to exploit, at least theoretically, a scarcity rent since they can ignore potential competitors outside the territorial district.

In-between collection and disposal, an intermediate step is placed; the separate waste collection or reuse-recycling segment. This segment is rooted in another EU principle: the Extended Producer Responsibility (EPR) Principle, which states that all subjects acting along the goods production and retail chains are responsible for the final diversion of those goods when transformed into waste at the end of their cycle. Besides the three specific application fields imposed by EU (packaging, electric and electronic devices, wood products), each Member State enjoys extensive autonomy in implementing the principle in other industries. When applied to the MWM issue, it means that each industry must guarantee the achievement of reuse-recover targets, as well as proper diversion of end-of-the-pipe materials. In a PP/SSP regime, EPR reduces the potential business for disposal facilities.

The combination of these principles lead to the establishment of a strict sub-regional market for MWM, a situation with no correspondence in other goods or services markets throughout the EU, and introduces real challenges of competition in the MW sector.

From an economic point of view, the PP/SSP seems to be irrational since MWM is composed of two segments, the upstream waste collection and the downstream waste disposal, with the first in a natural monopoly regime and the second dominated by mid- and large-size facilities (landfills, incinerators), forcing by law local communities to manage their own waste in a restricted area, generating all the conditions for a strong market power of disposal agents. As a result, the final outcome of this situation can be of three kinds:

1. Disposer squeezes the profit of Collector, if the former sets the price of disposing after Collector has set the price of collection services;
2. the final customer (the Local Council) pays an higher price for the service, due to the double marginalization operated by both the downstream and the upstream operators;
3. a public planner thoroughly regulates the disposal market or both disposal and collection markets and maximizes a social welfare function given by customer's utility, Collector's and Disposer's profits.

Is not surprising that where public regulation is more rigid, MWM is dominated by vertically integrated firms providing both collection and disposal services. Conversely, where regulation is more relaxed, one of the best strategies used by the Collector in order to escape the "capture" of Disposer is to foster a separated waste collection system. In this sense, we can see separated collection as a market competitor of end-of-the-pipe diversion, meaning that operating a first level selection of waste, selecting what can be reused and recycled as industrial raw materials, and sending only the residual parts to disposal facilities. It is easy to deduce that the higher the disposal toll (labelled a in the following model), the higher the quota of separated collection operated.

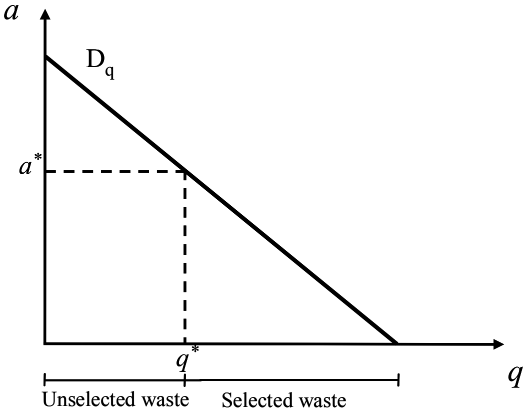

Figure 3.1 The demand for disposal of MW

In the following sections, we set up the general assumption and conditions for the model (Section 3.1), and depict a benchmark case where PP/SSP is enforced (Section 3.2). The benchmark is compared with the situation in which PP/SSP is relaxed and the disposing sector is opened to competition. We devise both an undifferentiated product framework (Section 3.3), and a differentiated one (Section 3.5), with the last one as a result of transportation costs in a Hotelling design. In all considered cases, opening the disposal sector to competition is detrimental to Municipal Waste selection and, consequently, to environmental quality. A total welfare analysis shows the positive and negative aspects of the implementation of PP/SSP in comparison with other fiscal instruments (Section 3.4). Within this general scheme, other topics are dealt with inside the Section 3.3, such as competition between disposing systems different for capacity constraints and technological efficiency, and vertical merger of Collector with Disposer.

3.1 The General Set up of the Model

We assume that a Local Council, representative of a municipal community and with no planning role in the market, produces the amount of MW Q, normalized at 1, and pays p to the sole Collector allowed to remove and divert the undifferentiated waste q ($q \leq Q$). Since removal of differentiated

MW – operated by the same Collector on demand from general producers – is free, the Local Council has an incentive to play the effort in domestic differentiation.

The Collector gets a unit p from the Local Council to remove undifferentiated MW and a different $\widetilde{p}$ from producers, in the rationale of EPR principle, or from firms using secondary raw materials in their industrial process (such as paper mills or glass factories), to select and direct to recycling differentiated MW. We assume that $\widetilde{p}$ is defined on the secondary raw materials market, but even that it is price-taken by local Collector, since the amount of selected waste d generated in each district is negligible with respect to the total demand for it at the market level. Following Fleckinger and Glachant (2010), another way to see it is that Producer Responsibility Organizations (PRO) that manage EPR on collective basis (see Par. 1.5.1) counterbalance the market power of Collectors, contributing to obtain the competitive price on this segment[19]

Once collected, the undifferentiated MW needs to be diverted. The Collector pays a unit toll a to a disposal facility owner to get the service. To reduce the quota of unsorted MW, obtaining the double gain of saving the related diversion costs and of getting the differentiated materials to be sold to recyclers, the Collector can contribute to increase the percentage of selected waste improving the ability of Local Council to differentiate. In order to act in this way, the Collector offers a "waste selection" capacity in terms of dedicated waste baskets and street bins, weekly collection schedules, educational booklets, and so on. On the Local Council side, they make an *effort* to produce the first separation of MW (selecting materials before throwing them away, carrying different packs of separated garbage in special street bins or, in case of kerbside collection, respecting specific norms and specific schedules to deliver it). Finally, a Disposer offers the diversion service for the unit toll a, and bears the relative unit costs c.

The three representative agents (Local Council, Collector, and Disposer) maximise the respective objective-functions.

For Local Council, the following is the utility function:

$$U_{LC} = \bar{u} - pq - e \qquad [3.1.1]$$

Where $\bar{u}$ is the gross utility of being delivered from MW; p is the unit price of the service, taken as given because of regulation by a Social Planner; $q \in [0,1]$ is the quantity of residual unsorted MW; $e \in R^+$ is the effort played by households when separated collection is available.

The quantity of selected MW d generated by the Local Council is obtained applying a "selection technology" to the total quantity of MW, a process whose functional form is expressed by the following Cobb-Douglas:

$$d = Q(ek)^{\frac{1}{2}}, \text{ where } Q = 1 \qquad [3.1.2]$$

Where e is the households' effort in [3.1.1], $k \in R^+$ is the differentiated collection capacity provided by the Collector. The rationale of this function is that differentiated waste d is an output of three essential inputs: raw material Q, labour e, and capital k. Each input can be compensated by the others, but the total amount of d falls to zero when the quantity of just a single input is nil: it is impossible to get differentiated MW with alternately no waste to differentiate, no effort by the households, nor any provision of differentiation capacity by the Collector. Since differentiated waste can

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[19] Notice that the participation of producers to the EPR system would be based upon the production level Q, and not on the selection level d. Nonetheless, the same PROs that gather this kind of fee from producers, buy selected materials by collection operators. In addiction, as pointed out in the previous lines Collectors can sell the secondary raw materials directly to final goods producers. For all this reasons, we simplified the model, applying the price $\widetilde{p}$ just to the quantity of selected waste d.

drop to zero, but it cannot be higher than the amount of total waste ($0 \le d \le 1$), the condition $(ek)^{\frac{1}{2}} \le 1$ applies. As a result, the residual unselected MW q is given by:

$$q = 1 - d = 1 - (ek)^{\frac{1}{2}} \qquad [3.1.3]$$

Plugging [3.1.3] into [3.1.1], we get the utility function to be maximised by Local Council with respect to e:

$$U_{LC} = \overline{u} - p\left(1 - (ek)^{\frac{1}{2}}\right) - e \qquad [3.1.4]$$

The sign of $\partial U / \partial e$ is ambiguous *a priori*: the domestic effort in waste differentiation is a direct cost for households, but on the other hand it is the only way to reduce the total cost of collection.

Collector takes MW away from Local Council area and is responsible for its diversion: he buys the requested capacity from a professional Disposer on the downstream market at the unit cost a. The revenue for the Collector comes from the Local Council, who pays p each unit of undifferentiated garbage removed, and from the EPR system/secondary raw materials users, who pay $\tilde{p}$ for the selected MW once recovered and bestowed by Collector.

As a matter of fact, both p and $\tilde{p}$ are given: the collection price p, because regulated by a Public Planner superior to the Municipality level (typically a regional one), and the price of recycled materials $\tilde{p}$ because the local supply d is too small to affect the price of the good at a regional or national level (see *supra*).

Besides the costs for disposing, the Collector also provides the facilities for Local Council to separate waste: in particular, they install a selection capacity k and investment in capacity has a quadratic cost[20]. For simplicity, we assume costs of collection and pre-treatment equal to zero[21]. Setting the transportation costs of undifferentiated MW to the disposing facility equal to zero (an assumption that will be removed in Section 3.5), the profit function of the Collector is:

$$\Pi_C = (p - a)q + \tilde{p}d - k^2 \qquad [3.1.5]$$

Substituting the functional form for q (i. e plugging [3.1.3] in [3.1.5]) and rearranging, we get:

$$\Pi_C = \tilde{p} + (p - a - \tilde{p})q - k^2$$
$$\Pi_C = (p - a)\left(1 - (ek)^{\frac{1}{2}}\right) + \tilde{p}(ek)^{\frac{1}{2}} - k^2 \qquad [3.1.6]$$

The Disposer is the owner of a facility (a landfill) appointed to deal with the fraction of MW not rescued nor addressed to recycling. They face marginal costs c and charges a unit price a, so that their profit function is:

$$\Pi_D = (a - c)q \qquad [3.1.7]$$

Putting for simplicity $c = 0$, and substituting the functional form of q:

$$\Pi_D = a\left(1 - (ek)^{\frac{1}{2}}\right) \qquad [3.1.8]$$

---

[20] Quadratic costs are assumed for analytical convenience but any convex function would not affect our results.

[21] Unconsidered costs include MW transportation to collection platforms, appointed personnel for waste selection duties after first collection from the households, investments in pre-treatment facilities.

The timing of the model is the following:

- at time $(t-1)$, a Collector is chosen as franchised or natural monopolist to operate in the collection market at the given unit price p; at the same $(t-1)$, the unit price $\widetilde{p}$ for separate collection is set;
- At t, the same Disposers maximise Π_D choosing the price a^* charged for the disposing service;
- At $(t+1)$ Collector observes a^* and maximises Π_C, choosing the quantity k^* of selection capacity to be provided to households.
- At $(t+2)$ Local Council maximises U_{LC} choosing the effort e^*.

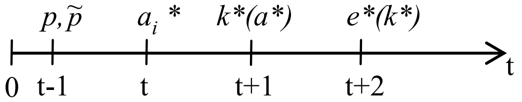

Figure 3.1.1 The timing of the model

The model is solved with backward induction.

3.2 The Benchmark: Implementing PP/SSP in the MW Industry

When a single Disposer is allowed to operate as a monopolist in a MWM (for instance in a defined district), the solution of the model is the following:

Stage 1

Local Council maximizes the utility function [3.1.4] with respect to e, i. e. choosing the right effort to reduce the fraction of undifferentiated MW q, whose (compulsory) removal is costly:

$$\max_{e} U_{LC} = \bar{u} - p\left(1-(ek)^{\frac{1}{2}}\right) - e$$

The first order condition is given by:

FOC: $$\frac{\partial}{\partial e}\left(\bar{u} - p\left(1-(ek)^{\frac{1}{2}}\right) - e\right) = \frac{p}{2}k^{\frac{1}{2}}e^{-\frac{1}{2}} - 1 = 0$$

From which: $$e^* = k\frac{p^2}{4} \qquad [3.2.1]$$

The effort e is directly related to the price of removing unselected MW and to capacity k provided by the Collector. The lower the capacity, the more futile is the effort played by households to select MW (when $k = 0$, any effort to produce selected MW would be unsuccessful).

Stage 2

The Collector maximizes his own profits [3.1.6] with respect to k:

$$\max_k \Pi_C = (p-a)\left(1-(ek)^{\frac{1}{2}}\right)+\tilde{p}(ek)^{\frac{1}{2}}-k^2$$

Plugging [3.2.1] into the previous equation and rearranging, we obtain:

$$\max_k \Pi_C = (p-a)\left(1-k^{\frac{1}{2}}\frac{p}{2}k^{\frac{1}{2}}\right)+\tilde{p}k^{\frac{1}{2}}\frac{p}{2}k^{\frac{1}{2}}-k^2=(p-a)+(\tilde{p}-p+a)\frac{pk}{2}-k^2$$

The first order condition is:

FOC: $$\frac{\partial}{\partial k}\left((p-a)+(\tilde{p}-p+a)\frac{pk}{2}-k^2\right)=(\tilde{p}-p+a)\frac{p}{2}-2k=0$$

which gives: $$k^* = \frac{p}{4}(\tilde{p}-p+a) \qquad [3.2.2]$$

As expected, the chosen differentiation capacity is directly related to the cost of landfill disposal service (*a*) and to the unit net revenue from selected MW conferring $(\tilde{p}-p)$.

Stage 3

The Disposer maximizes the profit function [3.1.8] with respect to *a*.

$$\max_a \Pi_D = a\left(1-(ek)^{\frac{1}{2}}\right)$$

Plugging [3.2.1] and [3.2.2] into the previous, and rearranging, we obtain:

$$\max_a \Pi_D = a\left(1-\frac{p^2}{8}(\tilde{p}-p+a)\right)$$

The first order condition is:

FOC: $$\frac{\partial}{\partial a}\left(a\left(1-\frac{p^2}{8}(\tilde{p}-p+a)\right)\right)=0$$

which gives: $$a^* = \frac{4}{p^2}+\frac{(p-\tilde{p})}{2}$$

The Disposer's toll is related to the difference between Collector's net revenues from unselected MW; the higher this difference, the lower the reaction of the Collector to shift to waste selection and, as a consequence, the higher the opportunity for the Disposer to raise *a*.

Plugging backward [3.2.3] into [3.2.2], [3.2.2] into [3.2.1], [3.2.1] and [3.2.2] into [3.1.3], we obtain the following values for the benchmark case variables:

$$a^M = \frac{4}{p^2}+\frac{(p-\tilde{p})}{2} \qquad [3.2.3]$$

$$k^M = \frac{1}{p}+\frac{p}{8}(\tilde{p}-p) \qquad [3.2.4]$$

$$e^M = \frac{p}{4}\left(1 + \frac{p^2}{8}(\tilde{p} - p)\right) \qquad [3.2.5]$$

$$q^M = \left(1 - \frac{p}{2}\left(\frac{1}{p} + \frac{p}{8}(\tilde{p} - p)\right)\right) = \frac{1}{2}\left(1 - \frac{p^2}{8}(\tilde{p} - p)\right) \qquad [3.2.6]$$

As expected, the quota of optimal unselected MW produced by the community is indirectly related to the differential between unit revenues from selected and unselected waste ($\tilde{p} - p$). Another way to see this point, is that q decreases whenever the shadow cost of undifferentiated waste is higher than the unit revenue $(\tilde{p} > p)$. The sign of the relation between q and p is ambiguous a priori, since higher values of p force the Collector to reduce the provision of k, so to favour the generation of unselected MW q, but they compel households (i.e. Local Council) to raise the effort e to reduce the expenditure. The "Collector" effect is caught by the last term of equation [3.2.6], while the "Local Council one is reflected by the $- p^2/8$ term.

A deeper analysis of equation [3.2.6] is provided in Appendix A.1.

3.3 Removing PP/SSP: Competition in MW Industry

In this Section, we take a look at the effects on the relevant variables when PP/SSP is not applied. To depict a situation where PP/SSP is removed, we assume that the disposing segment is open to competition, and the Collector can address MW both to the usual facility and to a non-district landfill. We consider the lower possible number of competitors: a duopoly with two landfills where to divert unselected MW.

3.3.1 A Bertrand Framework

According to Bertrand's duopoly theory, all operators offering an undifferentiated good will try to undercut the price charged by the rival until the price equals the marginal cost. In our case, the good is given by the straight service of MW landfilling, with no previous treatment, and no recovery of either raw materials or energy. The price name strategy in this scenario leads to:

$$a^B = c = 0 \qquad [3.3.1]$$

With all other conditions unchanged, the optimization functions of agents different from Disposers give the same [3.2.1], [3.2.2], and [3.1.3]. Plugging [3.3.1] in the previous, we obtain the values that solve the problem in a Bertrand framework:

$$k^B = \frac{p}{4}(\tilde{p} - p) \qquad [3.3.2]$$

$$e^B = \frac{p^3}{16}(\tilde{p} - p) \qquad [3.3.3]$$

$$q^B = 1 - \frac{p^2}{8}(\tilde{p} - p) \qquad [3.3.4]$$

We find an amount of unselected MW that is twice the quantity of PP/SSP, even if selected MW does not fall to zero[22]. Reducing a to the marginal cost of disposing makes waste selection less profitable for the Collector, so that even e and k at equilibrium are lower.

It is interesting to notice that the particular service provided by a landfill is subjected to capacity constraint. This means that in setting the price of the service a^*, prior to beginning a price war aimed at dropping the rival off the market, the duopolist must take into account if they are able to cover the total demand. Following Kreps and Sheinckman (1983), this claims for a two-steps procedure, where first the capacity is chosen, and then the price of the service is named. In our model, it means introducing another step where the Disposer decides the dimension of the landfill, before choosing the price of disposing:

- at time $(t-2)$, a Collector is chosen as franchised or natural monopolist to operate in the collection market at the given unit price p; at the same $(t-2)$, the unit price $\tilde{p}$ for separate collection is set;
- At $(t-1)$, Disposers pre-commit on the quantity of unselected MW they can operate, establishing the capacity of their landfills;
- At t, the same Disposers maximise Π_D choosing the price a^* charged for the disposing service;
- At $(t+1)$ Collector observes a^* and maximises Π_C, choosing the quantity k^* of selection capacity to provided to households.
- At $(t+2)$ Local Council maximises U_{LC} choosing the effort e^*.

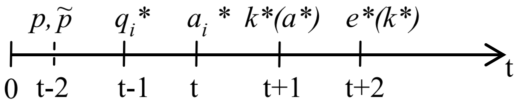

Figure 3.3.1: The timing of the model with precommitment

3.3.2 The Precommitment Issue

Due to the undifferentiated nature of the disposing service, precommitting to capacity means deciding the maximum quantity of MW each Disposer is willing to operate, considering both the demand's dimension and the presumed capacity of the rival.

With all the other segments of the MW industry unchanged, if we consider a technological equivalence of the duopolists, the Stage 3 of the backward induction problem can be solved in a Cournot framework, giving an outcome in terms of best response functions (BRF) of the two Disposers:

$$\max_{q_i} \Pi^i{}_D = aq_i,\ i = 1,\ 2 \qquad [3.3.5]$$

---

[22] In order to see this, we can recall the assumption introduced in [3.1.2], that $(ek)^{1/2} \leq 1$. Applying it to the Bertrand outcomes means $\left(e^B k^B\right)^{1/2} = \frac{p}{2} k^B = \frac{p^2}{8}(\tilde{p} - p) \leq 1$. And plugging this in [3.3.4], we get a value into the brackets lower than one.

The optimization problems in Stages 1 and 2 are the same as in the Monopoly case (i. e. when PP/SSP rules), so that arranging [3.2.1], [3.2.2], and [3.1.3], we obtain the value of *a* [3.3.6] to be plugged into [3.3.5][23]:

$$a = (p - \tilde{p}) + \frac{8}{p^2}(1 - q)$$

$$a = (p - \tilde{p}) + \frac{8}{p^2}\left(1 - \sum_i^2 q_i\right) \qquad [3.3.6]$$

The maximization problem in [3.3.5], is:

FOC: $$\frac{\partial}{\partial q_i}\left((a(q_i + q_j))q_i\right) = 0, \qquad i, j = 1, 2$$

$$\frac{\partial}{\partial q_i}\left(\left((p - \tilde{p}) + \frac{8}{p^2}\left(1 - (q_i + q_j)\right)\right)q_i\right) = \frac{8}{p^2}\left(1 - (q_i + q_j) + (p - \tilde{p}) - q_i\right) = 0$$

With the BRF of the *i-th* operator given by:

$$q_i = \frac{1}{2}\left(1 - \frac{p^2}{8}(\tilde{p} - p) - q_j\right) \qquad [3.3.7]$$

Being q_i the total capacity of the *i-th* landfill, once the choice is made it could not be changed, and the occupancy ratio of the facility will depend on the toll a_i named by the Disposers at the next step of the game[24].

If the Disposer *i* is persuaded they could win a price war and send off the rival off the market, their choice would coincide with the previous [3.3.7] when $q_j = 0$, i. e. they would install the monopoly capacity (see [3.2.6]). However, being the duopoly symmetric this would mean a total capacity in the market would double with respect to the monopoly case:

$$q = 1 - \frac{p^2}{8}(\tilde{p} - p)$$

That is exactly the outcome of the Bertrand competition (see [3.3.4]).

This conclusion is an important hint for the equilibrium that would arise at the price naming stage, and a strong signal for the strategy to play at the previous capacity stage due to the symmetric nature of the game. Once any Disposer has established a monopoly capacity, the only way to fill it is setting a price of the landfill service equal to marginal costs, however, the maximization of profits for both duopolists leads to a different option.

Because of the symmetric nature of the problem, the intersection of the BRFs [3.3.7] gives:

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[23] Rearranging [3.2.2] we obtain a value for *a* in terms of *k*, namely: $a = (p - \tilde{p}) + 4k/pQ^2$. Plugging [3.2.1] in [3.1.3] we obtain $k = (2/p)(1 - q)$, and substituting the last one in the previous, we obtain [3.3.6].

[24] Following Davidson and Deneckere (1986), the pre-commitment issue can be considered a game where the first stage is a quantity competition problem in the long-run, while the second stage is a price competition problem in the short-run.

$$q_1 = q_2 = \frac{1}{3}\left(1 - (\tilde{p} - p)\frac{p^2}{8}\right) \qquad [3.3.8]$$

That leads to the Nash-Cournot equilibrium:

$$q^{NC} = \frac{2}{3}\left(1 - \frac{p^2}{8}(\tilde{p} - p)\right) \qquad [3.3.9]$$

By pre-committing to install a constraint capacity equal to [3.3.8], the two Disposers avoid fighting a price war that would end in the Bertrand equilibrium, eroding to nil their profits.

Exactly in the track of Kreps and Sheinckman (1983), we can conclude that in an oligopoly where price competition *à la* Bertrand follows the simultaneous declaration of the maximum production levels by the agents, the unique equilibrium is a Nash-Cournot outcome.

The value of the other relevant variables are:

$$a^{NC} = \frac{8}{3p^2} + \frac{(p - \tilde{p})}{3} \qquad [3.3.10]$$

$$k^{NC} = \frac{2}{3p} + \frac{p}{6}(\tilde{p} - p) \qquad [3.3.11]$$

$$e^{NC} = \frac{p}{6}\left(1 + \frac{p^2}{4}(\tilde{p} - p)\right) \qquad [3.3.12]$$

Returning to the issue of competition, comparing [3.3.9] with [3.2.6], it is easy to grasp that the removal of PP/SSP ingenerates a higher recourse to landfill, i.e. a higher production of unselected MW. Moreover, with the assumption of a direct connection between unsorted MW and externalities, due to soil occupation, dioxide emissions from landfill or incinerators and aquifer pollution from percolation, resulting in higher environmental damage.

Remark 3.3.1

A higher competition in the disposal segment induces the Collector to shift from waste selection to landfill disposing. The final consequences are a higher generation of unselected MW and of the related environmental externalities.

3.3.3 Different Disposing Systems and Market Contestability

Many districts throughout Europe have been recently interested by the entry of incineration technologies in the disposal segment of the waste industry. With respect to landfilling, the advantages of waste incineration are threefold. Firstly, contrary to landfills, incinerators do not suffer from long run capacity exhaustion[25]. Secondly, they are more efficient than landfills in treating waste, meaning a lower marginal cost at the standard use and finally, as pointed out in Chapter 1, modern incinerators allow a profitable energy recovery from waste.

At the same time, incinerators appear to be disadvantaged with respect to landfills because of the higher sunk costs they entail. It is worth asking if this feature could be detrimental to the contesta-

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[25] This is not true in the short run, when incineration has a constraint in the size of waste they can treat in a single period. However for incinerators, capacity is a flow, to be repeated each period net of usage loss, while for landfills it is a stock reduced with time. Since we run a short run analysis, hereinafter this characteristic is ignored.

bility of the disposal segment and, consequently, to the potential degree of efficiency that the market could achieve.

The issue, that dates back to the limit pricing model of Bain-Sylos Labini-Modigliani, and the well-known "Sylos Postulate" (Bain, 1956; Modigliani, 1958, Sylos-Labini, 1962), has been raised in the waste industry by Massarutto (2007), who claims the opportunity for landfill owners to "credibly threaten to lower their prices after the incinerator starts operating". If they do so, only the remaining quantity of waste will be available to incinerators, after the first quantity has been landfilled. Therefore, (…) the remaining market share might not be sufficient to justify investment"[26].

The Sylos Postulate has been subjected to a well known criticism by game theorists (Spence, 1977 and 1979; Selten, 1978; Dixit, 1980), because of the subgame non-perfect condition of the equilibrium arising from it. When applied to the waste issue, we can argue against Massarutto (2007) that the menace of the landfill owner is unreliable and two possibilities could occur: either accommodating is more profitable for the incumbent (landfill), who will share the market with the new entrant (incinerator) at the duopoly price, or – when more efficient – the entrant can price under the incumbent's marginal cost to gain the whole market. In both cases, investment costs and entrance are fully justified for the outsider.

However, due to the selected collection option, a deterrence against a most efficient incinerator entrance is still available. The price limit role, in this case, is played by the gap existing between the unit revenues gained by the Collector from unsorted waste and from selected waste collection $(p-\tilde{p})$.

To follow this intuition, we reintroduce a positive marginal cost for disposal $c \neq 0$, that gives a profit function to the Incumbent (landfill) equal to [3.1.7]. We consider a potential entrant (incinerator) with lower marginal costs than the Incumbent $(c - \beta)$, because both being more efficient in treating waste, and more able to extract revenue from energy recover, but burdened by sunk costs higher than zero $(F > 0)$. The total cost function of the incinerator (labelled as "Outsider") is:

$$C_O = F + (c-\beta)q \qquad [3.3.13]$$

With average cost given by:

$$AC_O = \frac{F}{q} + (c-\beta) \qquad [3.3.14]$$

And the consequent profit function:

$$\Pi_O = (a - \frac{F}{q} - c + \beta)q \qquad [3.3.15]$$

According to the Sylos postulate, an incumbent with marginal cost c would set the landfill toll at $a = \frac{F}{q} + (c-\beta) - \varepsilon$, i.e. he would price the disposal service under the average cost of the incinerator. As a consequence, the entry of the Outsider will not occur, since they could not recover the investment cost bore to establish the incinerator plant. Once the entry is deterred, the incumbent restores the monopoly price.

Such a scenario, the same sketched by Massarutto (2007), is undesirable from a welfare perspective, since it would induce the more efficient disposal solution to stay out of the industry. However, according to the game theory framework, the price war is not a reliable option, since the best response by the Incumbent to Outsider's entry is to accommodate – i.e. to play the oligopoly strategy

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[26] Massarutto A., 2007, p. 12.

- and share the market with the entrant[27]. The different outcomes of the entry game are the following.

Price war

The incumbent triggers a price war, setting $a_I = AC_O - \varepsilon$, even though it means a loss in the short run:

$$a_I = \frac{F}{q} + (c - \beta) - \varepsilon \qquad [3.3.16]$$

A predatory price fitting with [3.3.16] is $a_I = c - \beta$, that generates the following quantity of disposed MW:

$$\Pi_O = (a - \frac{F}{q} - c + \beta)q_O = -\frac{F}{q_O}q_O = -F < 0$$

$$\Pi_I = (c - \beta - c)q_I = -\beta q_I < 0 \qquad [3.3.17]$$

$$q = q_I = 1 - \frac{p^2}{8}\left(\tilde{p} - p + c - \beta\right) \qquad [3.3.18]$$

Besides the value of q, the relevant outcome of the price war is that both operators would incur a loss, and it is a sufficient threat for the outsider not to enter the market. Therefore, the disposal industry continues being a monopoly, but with only the most inefficient technology available.

Entry and accommodation

The Outsider and the Incumbent maximize the personal profits in a Cournot framework, according to their respective BRFs. Because of the different levels of efficiency, showed by different marginal costs, the market sharing is not symmetric:

$$\max_{q_I} \Pi^I{}_D = \left(a - c\right)q_I$$
$$\max_{q_O} \Pi^O{}_D = \left(a - c + \beta\right)q_O - F \qquad [3.3.19]$$

And, adapting [3.3.6]: $a = \left(p - \tilde{p}\right) + \frac{8}{p^2}\left(1 - \left(q_I + q_O\right)\right)$

The FOC are: $\frac{\partial}{\partial q_i}\left(\left(a\left(q_i + q_j\right)\right)q_i\right) = 0, \qquad i, j = I, O$

With different BRF for each operator, because of their dissimilar efficiency:

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[27] Modern versions of the limiting price model deal with imperfect information (Kreps and Wilson, 1982; Milgrom and Roberts, 1982), and with the so called "long purse", i.e. the asymmetric financial capacity of incumbents and entrants (Benoit, 1984; Fudenberg and Tirole, 1985; Holmstroem and Tirole, 1997). None of these frameworks fits with our setting: the first one because we consider perfect information; the second, because companies establishing incinerators are usually more capitalized than landfill owners.

$$q_I = \frac{1}{2}\left(1 - \frac{p^2}{8}(\tilde{p} - p + c) - q_O\right)$$

$$q_O = \frac{1}{2}\left(1 - \frac{p^2}{8}(\tilde{p} - p + c - \beta) - q_I\right) \qquad [3.3.20]$$

Equilibrium at:

$$q_I^{NC} = \frac{1}{3}\left(1 - \frac{p^2}{8}(\tilde{p} - p + c + \beta)\right)$$

$$q_O^{NC} = \frac{1}{3}\left(1 - \frac{p^2}{8}(\tilde{p} - p + c - 2\beta)\right)$$

$$q = q_O^{NC} + q_I^{NC} = \frac{2}{3}\left(1 - \frac{p^2}{8}\left(\tilde{p} - p + c - \frac{\beta}{2}\right)\right) \qquad [3.3.21]$$

$$a = \frac{8}{3p^2} + \frac{p - \tilde{p} + 2c - \beta}{3}$$

And profits given by:

$$\Pi_I = (a - c)q_O = \frac{1}{9}\left[\frac{8}{p^2} + 2(p - \tilde{p} - c - \beta) + \frac{p^2}{8}(p - \tilde{p} - c - \beta)^2\right]$$

$$\Pi_I = \frac{1}{9}\left[\frac{8}{p^2} + (p - \tilde{p} - c - \beta)\right]^2 \geq 0 \qquad \forall(p - \tilde{p} - c - \beta)$$

$$\Pi_O = (a - c + \beta - \frac{F}{q_O})q_O = \frac{1}{9}\left[\frac{8}{p^2} + 2(p - \tilde{p} - c + 2\beta) + \frac{p^2}{8}(p - \tilde{p} - c + 2\beta)^2\right]$$

$$\Pi_O = \frac{1}{9}\left[\frac{8}{p^2} + (p - \tilde{p} - c + 2\beta)\right]^2 \geq 0 \qquad \forall(p - \tilde{p} - c + 2\beta) \qquad [3.3.22]$$

The Entry Game Solution

Evaluating all the possible outcomes arising from the set of strategies of the two players is useful. In order to have a complete picture, we still have to consider the pay off in the case, which is actually quite improbable, that incumbent accommodates to the entry, but the outsider stays out the same.

In this case, the incumbent reacts according to the BRF in [3.3.20], but the measure of MW diverted in the landfill by the Outsider is $q_O = 0$.

This means, adapting [3.3.6] once more: $a = (p - \tilde{p}) + \frac{8}{p^2}(1 - q_I)$

That gives, after some calculation:

$$\Pi_I = \frac{1}{4}\left[\frac{8}{p^2} + (p - \tilde{p} - c)\right]^2 \geq 0 \qquad \forall (p - \tilde{p} - c) \tag{3.3.23}$$

The comparison of the whole pay off scheme is resumed in the following game tree representation:

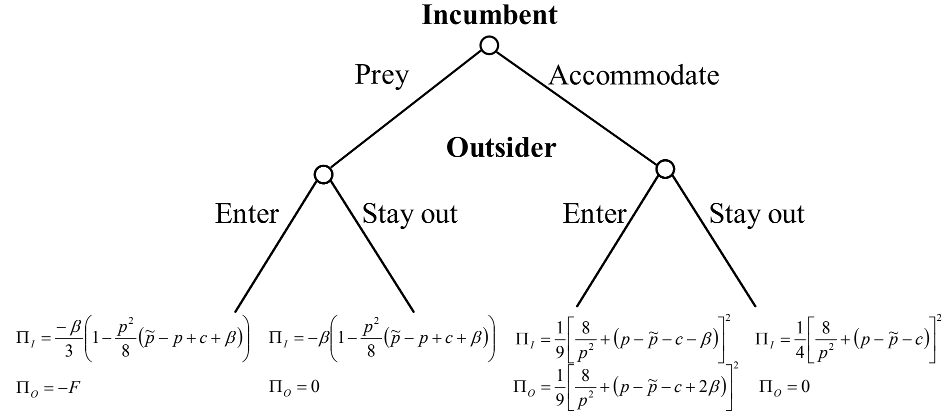

Figure 3.3.2: The entry game. A tree representation

It is easy to see that *Accommodate* is a dominant strategy for the incumbent, and that the only sub-game perfect equilibrium is with an outsider that enters and an incumbent that accommodates. As a matter of fact, it is not credible that an incumbent triggers a price war once investment cost F occurs. The price limit described in [3.3.16], or the simple $a_I = c - \beta$, will not be played by a rational operator, and no barrier is raised against the entry of the incinerator.

This means that the final outcome is a duopoly where both Incumbent and Outsider operates and the quantity of unsorted MW produced is equal to [3.3.21], that is higher not only than the monopoly case, but even than the duopoly case when $\beta = 0$ (see [3.3.9] for a comparison)

Due to the fact that β can be interpreted not only as a technological advantage in MW disposal, but even as the revenue from the collateral activity of energy production, this result is relevant.

Remark 3.3.2

The implementation of waste-to-energy technology is detrimental to MW selection and fosters final waste production.

It is worth wonder if, once the entry had occurred, the competition would end in a duopoly or if the more efficient operator (the incinerator) would exclude the rival from the industry, setting the disposal price at $a_O = c - \varepsilon$, $\varepsilon < \beta$.

This is an available option whenever the incinerator profits are higher in monopoly than in duopoly, i.e. they recover in demand size the loss in terms of unit revenue due to the exclusionary pricing strategy. Comparing a reduced version of the incinerator profit equation in both cases, this would mean:

$$\Pi^M{}_O = (c - c + \beta - \frac{F}{q^M{}_O})q^M{}_O = \beta q^M{}_O - F > \Pi^D{}_O = (a - c + \beta - \frac{F}{q^D{}_O})q^D{}_O = (a - c + \beta)q^D{}_O - F\,,$$

and, after a rearrangement:

$$\frac{q^M{}_O - q^D{}_O}{q^D{}_O} > \frac{a-c}{\beta} \qquad [3.3.24]$$

Without going any further, we see that the left hand of inequality [3.3.24] is the percentage measure of the rise in the quantity of unselected materials treated by the more efficient facility from cutting out the Incumbent. Whenever this value is higher than the threshold on the right hand, the substitution of the Incumbent is convenient for the outsider. The measure of the threshold is directly proportional to the cost of cutting out the rival (the unit revenue Outsider have to give up because of playing an exclusionary price) and inversely proportional to the profits from energy production (the revenue extracted from each waste unit): the higher this latter value, the higher the probability of substitution of the landfill with the more efficient incinerator.

Entry Barrier

The different options discussed in the previous sections are outlined in figure 3.3.3 representing the disposal segment of the MWM: D_q is the demand for disposal, AC_O is the average cost curve of the incinerator, c and $(c-\beta)$ are the marginal costs of landfill and incinerator, respectively.

Conditions exist in the model for the simultaneous operating of both landfill and incinerator, with a total quantity of end-of-the-pipe diverted MW ranging from q^S to $q(c)$, and for business stealing by an entrant incinerator, with a correspondent quantity of disposing ranging from $q(c)$ to $q(p_L)$, while a price war scenario favouring a MW disposal beyond $q(p_L)$ is unreliable.

From figure 3.3.3, we can see that even a minimum threshold does exist for q, and that the entry of the incinerator seems to have a deterrence in $a = a^S$.

Price limit a^S could not be played strategically by the incumbent; however, it could delimit an area where the less efficient landfill exerts as a monopolist. This happens because of the influence of $(p-\tilde{p})$ on a.

As a matter of fact, the monopolistic landfill set the price according to [3.2.3], i.e. at $a^M = \frac{4}{p^2} + \frac{(p-\tilde{p})}{2}$.

To deter the entry of the Outsider, the required condition is $a^M < AC_O$:

$$a^M = \frac{4}{p^2} + \frac{(p-\tilde{p}+c)}{2} \le (c-\beta) + \frac{F}{q^M} \qquad [3.3.25]$$

Substituting [3.2.6] into [3.3.25], considering $c \neq 0$, and rearranging, we obtain:

$$\frac{4}{p^2} + \frac{(p-\tilde{p}+c)}{2} - c + \beta \le \frac{F}{\frac{1}{2}\left(1 - \frac{p^2}{8}(\tilde{p}+p-c)\right)}$$

$$\frac{p^2}{16}(p-\tilde{p}-c)^2 + (p-\tilde{p}-c)\left(1+\frac{p^2}{8}\beta\right) + \left(\frac{4}{p^2}+\beta-2F\right) \le 0 \qquad [3.3.26]$$

That is the functional form of a concave parabola with $(p-\tilde{p}-c)$ as independent variable, and roots in:

$$(p-\tilde{p}-c)_1 = -\frac{1}{p^2}\left(8+p^2\beta+p\sqrt{32F+p^2\beta^2}\right), \qquad \text{and}$$

$$(p-\tilde{p}-c)_2 = -\frac{1}{p^2}\left(8+p^2\beta-p\sqrt{32F+p^2\beta^2}\right)$$

Equation [3.3.26] holds for all values belonging to the interval included between the two roots.

The first one is always negative for reliable values of parameter (i.e. positive or nil). In addiction, it is lower than $-8/p^2$, the value below which the price of the disposal service *a*, becoming negative, is inconsistent. For this reason, we must reconsider the minimum threshold for $(p-\tilde{p}-c)$, that is equal to $-8/p^2$.

The second root can be positive under the same conditions for the parameters, when the square root term is higher than the absolute value of the sum of remaining terms:

$$(p-\tilde{p}-c)_2 > 0 \qquad \textit{iff} \qquad \frac{\sqrt{32F+p^2\beta^2}}{p} > \frac{8}{p^2}+\beta$$

Expanding the inequality and rearranging, we get that the condition of positivity holds when:

$$F > \frac{2}{p^2}+\frac{\beta}{2} \tag{3.3.27}$$

This means that a barrier to entry could exist for the more efficient incinerator, even thought it is exogenous and not raised by the incumbent. The barrier is related to the value of $(p-\tilde{p}-c)$; dropping *c* for simplicity, i.e. considering the higher efficiency of the incinerator given by the opportunity to produce and sell energy, we focus directly on $(p-\tilde{p})$. When the difference between p and $\tilde{p}$ is close to zero or negative, the Collector at Stage 2 is boosted forward waste selection. As a consequence, the demand for disposal services is too low to cover the investment *F*. Not surprisingly, the higher the size of *F*, the higher is the threshold in order to enter the market.

Remark 3.3.3

While Incumbent's menace to play a price limit strategy is not reliable, the entrance of a more efficient competitor with non-null sunk costs can be deterred when the value of the difference $(p-\tilde{p})$ is either negative $(p<\tilde{p})$ or it is lower than a threshold directly proportional to F.

The analysis allows to complete the picture with the missing segment: when $q < q^S$ a barrier to entry of the Outsider is effective, and the incumbent landfill acts as a monopolist.

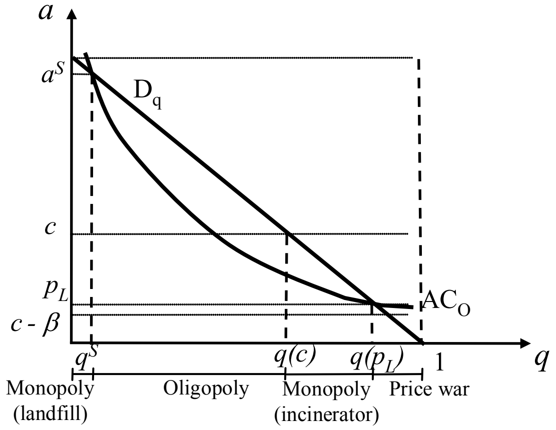

Figure 3.3.3: Demand and supply for disposal of MW with different disposing systems

3.3.4 Vertical Integration

Another issue to be dealt with is related to the case of vertical merger between Collector and Disposer. In previous pages, we observed that the European waste market is often characterized by vertically integrated firms that provide a whole service of collection and diversion (see Chapter 1). This is the result of an enduring evolution, driven by both the will of the Collector to escape from price squeezing by Disposer, and the need of the latter to feed the facility they manage, mainly when it is an incinerator.

The vertical merger between an upstream and a downstream operator involves the competition issue (for a review see Perry, 1989)[28], since it can be used as a strategy to foreclose competitors. In the waste industry, the opportunity for managing an all inclusive service allows integrated operators both to offer a lower collection price in public auctions and tenders, and to exclude potential rivals in the disposing segment.

Since in the model the Collection service price p is taken as given, in this Section we do not consider the competition problem, and we focus on the effect of a vertical merger on the total quantity of diverted MW. It is easy to prove that the merger generates efficiency gains for the integrated operator, allowing him to provide a higher quantity of disposal service at a lower price.

In order to observe this, we need to reframe the timeline, offsetting Stage 3 and considering a Vertical Integrated operator that offers k watching not at a, but at the marginal cost c of disposing:

$$\Pi_{VI} = (p-c)\left(1-(ek)^{\frac{1}{2}}\right)+\tilde{p}(ek)^{\frac{1}{2}}-k^{2} \qquad [3.3.28]$$

Plugging [3.2.1] into [3.3.28], the new version of FOC is:

FOC: $$\frac{\partial}{\partial k}\left((\tilde{p}-p+c)\frac{pk}{2}-k^{2}\right)=(\tilde{p}-p+c)\frac{p}{2}-2k=0$$

which gives: $$k^{VI}=\frac{p}{4}(\tilde{p}-p+c) \qquad [3.3.29]$$

Bypassing the calculation of e^{VI}, the final value of q^{VI} is obtained plugging [3.3.29] and [3.2.1] into [3.1.3]:

$$q^{VI}=1-\frac{p}{2}\left(\frac{p}{4}(\tilde{p}-p-c)\right)=1-\frac{p^{2}}{8}(\tilde{p}-p-c) \qquad [3.3.30]$$

That is equivalent to Bertrand competition (or perfect contestability) in disposing when $c \neq 0$ (see [3.3.4]).

The merger between Collector and Disposer pushes the disposing to the maximum level, and only a higher unit revenue for MW selection with respect to unsorted collection $(\tilde{p}-p)$ could avoid the landfilling of the whole MW produced.

The reason of this outcome is straightforward: the merger allows the Vertically Integrated operator to divert at a lower cost than in the disjointed industry, since both monopolist and oligopolist Disposers priced the service charging a mark up on the marginal cost. Abating the mark up to zero, in a situation where price p is given, increases the offer to the maximum.

This is an important point to be highlighted, since in many European regions and districts, the vertical integration of agents operating at different stages of the waste industry has become an increasingly adopted practice, motivated with the exploitation of efficiency gains.

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[28] Not surprisingly, since 2004 vertical mergers have been the subject of a specific EU Merger Control Regulation.

Remark 3.3.4

The vertical integration of Collector and Disposer reduces the interest in MW selection and fosters final waste production.

Finally, notice that, due to the absence of sunk costs, the entrance of a new non-integrated Disposer with marginal costs lower than c would still be viable. As a matter of fact, in this case it would be more profitable for the Vertically Integrated operator to collect an even higher quota of unsorted waste, and to address it to the rival's landfill. This last strategy would end in a further increase of the unsorted MW[29].

3.4 Welfare Analysis

From an environmental economics perspective PP/SSP can be considered a command and control standard, enforced by the Social Planner to hit an environmental target that would be missed otherwise.

A large environmental and public economics literature has pointed out that the same objective in terms of externality reduction can be reached with different tools, ranging from the strict regulation of command and control standards to the market inspired solution of negotiation *à la* Coase (for a review, see Kolstad, 2000). In our case, it is worth asking if the target of a controlled pollution from disposing could be achieved with some other internalization policy, namely a Pigouvian tax, with a parallel increase in total welfare.

In next pages we calculate the optimal tax that maximize the Total Welfare and compare the resultant equilibrium with the one corresponding to PP/SSP.

Opening the disposal market to competition would boosts the quantity of unselected MW at q higher than q^M. If the Social Planner wants to internalize the higher environmental impacts related to q, he can levy a Pigouvian tax equal to τ[30].

The introduction of the tax requires a change in the timeline. One possible representation of the subsequent steps is the following:

- at time $(t-2)$, the Social Planner chooses the optimal tax τ^* in a regime of removed PP/SSP;
- At $(t-1)$ and t, Disposers pre-commit on the quantity and observe τ^* to name the price a^* that maximises the respective $\Pi^i{}_D$;
- At $(t+1)$ Collector observes a^* and chooses k^* to maximise Π_C;
- At $(t+2)$ Local Council observes k^* and chooses the effort e^* to maximise U_{LC}.

We first solve the public authority problem, and then find the value of relevant variables in equilibrium with the new parameter τ. Then, we compare the total welfare with PP/SSP, and with competition plus Pigouvian tax.

When taxation is charged on the Disposer, the backward solution for steps 1 and 2 remains the same.

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[29] This strategy is not favourable when the integrated facility is an incinerator, both for the need to cover fixed costs and for the opportunity to increase revenues from the production and trade of energy.

[30] Notice that the Social Planner's problem could be solved even choosing an optimal p, instead of levying a Pigouvian tax on Disposer(s) or Collector. Nonetheless, given the setting of the model, the mathematical extraction of the optimal p would be undefined, while the identification of the requested τ is straight. The simultaneous use of regulated prices and tax schemes is compatible with the real MW industry, where we see the workability of both ceiling price of integrated service and landfill taxes.

Recovering [3.2.1], [3.2.2], and [3.1.3], we can reframe the maximization problem of Disposers as follows:

Step 3

$$\max_{q_i} \Pi^{i}{}_{D} = (a-\tau)q_i\,,\ i = 1,\ 2 \qquad [3.4.1]$$

Plugging in [3.2.1], [3.2.2], and [3.1.3], and using [3.3.4], the maximization problem in [3.4.1], is:

FOC: $$\frac{\partial}{\partial q_i}\left((a(q_i+q_j)-\tau)q_i\right)=0\,,\quad i, j = 1,\ 2$$

That leads, once identified the BRF, to the equilibrium with τ:

$$q(\alpha)=\alpha\left[1-\frac{p^2}{8}(\tilde{p}-p+a+\tau)\right] \qquad [3.4.2]$$

Where α is the parameter reflecting the market regime of the disposal sector ($\alpha \in [½, 1]$). As a matter of fact, we consider a general version of [3.3.5], where the value taken by parameter α gives the amount of disposed MW related to the number of disposers:

Step 4

With landfill tax, the problem entails a fourth and final step, where the public authority sets the optimal value of τ to maximize TW.

$$\begin{aligned}
&\underset{\tau}{Max}\,TW(\alpha)=U_{LC}+\Pi_C+\Pi_D(\alpha)-\tilde{p}(1-q(\alpha))+TR-\phi q(\alpha)=\\
&\bar{u}-pq(\alpha)-e(\alpha)+(p-a)q(\alpha)+\tilde{p}(1-q(\alpha))-k(\alpha)^2+(a-\tau(\alpha))q(\alpha)-\tilde{p}(1-q(\alpha))+\tau(\alpha)q(\alpha)-\phi q(\alpha)\\
&=\underset{\tau}{Max}\,TW\left(\bar{u}-e(\alpha)-k(\alpha)^2-\phi q(\alpha)\right) \qquad [3.4.3]
\end{aligned}$$

The Social Planner find the optimal τ^* and the corresponding q^*. Plugging [3.2.1], [3.2.2], [3.3.4] and [3.4.2] in [3.4.3] and maximizing, we obtain:

$$\frac{\partial\left(\bar{u}-e(\alpha)-k(\alpha)^2-\phi q(\alpha)\right)}{\partial\tau}=0\to\ldots\to$$

$$\tau(\alpha)^*=\frac{8}{p^2}\left(1-\frac{1}{\alpha}\right)+\frac{\phi}{\alpha}+p\left(1-\frac{1}{2\alpha}\right)-\tilde{p} \qquad [3.4.4]$$

and:

$$q^*=1-\frac{p^2}{8}\left(\phi-\frac{p}{2}\right) \qquad [3.4.5]$$

This leads to a relevant result: the optimal amount of disposing is inversely related to the unit environmental damage ϕ, but it is the same for any value of α, i.e. for any organizational form taken by the disposing industry. On the contrary, the optimal level of the tax [3.3.11] changes according to α. The sign of the relation is ambiguous *a priori*, since:

$$\frac{\partial\tau^*}{\partial\alpha}=\frac{8}{p^2\alpha^2}+\frac{p}{2\alpha^2}-\frac{\phi}{\alpha^2}=\frac{1}{\alpha^2}\left(\frac{8}{p^2}+\frac{p}{2}-\phi\right) \qquad [3.4.6]$$

meaning:

$$\frac{\partial\tau^*}{\partial\alpha}\geq 0 \;\; iff \;\; \phi\leq\frac{8}{p^2}+\frac{p}{2} \qquad [3.4.7]$$

Considering the existence interval for q ($q \in [0, 1]$), we see that:

$$0\leq q^*\leq 1\rightarrow\frac{p}{2}\leq\phi\leq\frac{8}{p^2}+\frac{p}{2} \qquad [3.4.8]$$

Comparing [3.4.8] with [3.4.7] we can see that the last inequality is true for any significant value of q: this means that the optimal Pigouvian tax is both increasing in ϕ (the higher the environmental impact of disposing, the higher the optimal tax rate), and even in α (the higher the number of allowed disposers, the higher the tax rate): the variability of τ^* makes it that q^* does not change at equilibrium. Equation [3.4.4] shows even that τ is affected by the gap between p and $\tilde{p}$: if the gap is low or negative (i.e. the two prices are close or recycling is more convenient than conventional collection), the optimal level of the Pigouvian tax is lower, since the market discourages the generation of unsorted MW.

Remark 3.4.1

Given the unit environmental impact of MW disposing, the optimal Pigouvian tax to be levied on disposed MW increases with the number of disposers, while the optimal percentage of disposing is constant.

It is worth asking at which condition q^* is equivalent to q^M, i.e. to the quantity of disposing corresponding to the PP/SSP, and at which condition the equality do not hold. To answer we set the equation:

$$q^*=1-\frac{p^2}{8}\left(\phi-\frac{p}{2}\right)=\frac{1}{2}\left[1-\frac{p^2}{8}(\tilde{p}-p)\right]=q^M \qquad [3.4.9]$$

This happens when:

$$\phi=\frac{4}{p^2}+\frac{\tilde{p}}{2} \qquad [3.4.10]$$

In this case, the values assumed by the relevant variables at equilibrium are the following

Market regime in disposing	***Pigouvian tax***	***Quantity of unsorted MW***
Monopoly *(α = ½)*	$\tau^*=0$	$q^*=\frac{1}{2}\left(1-\frac{p^2}{8}(\tilde{p}-p)\right)$
Cournot competition *(α = 2/3)*	$\tau^*=\frac{2}{p^2}+\frac{p-\tilde{p}}{4}$	
Bertrand competition *(α = 1)*	$\tau^*=\frac{4}{p^2}+\frac{p-\tilde{p}}{2}$	

Table 3.4.1: The Values of Relevant Variables at Equilibrium when $q^*=q^M$

It is confirmed that while q^* leaves unchanged, the Pigouvian tax changes from nil (when there exist a single disposer, i.e. when PP/SSP applies) to a value that doubles from Cournot to Bertrand competition.

Reframing Figure 3.1, we see that opening the disposal market to competition (for instance a Cournot competition) would boost the quantity of unselected MW at q^{NC}. If the Social Planner wants to restore the total q at q^M for environmental reasons, he can enforce the PP/SSP, or alternatively levy a Pigouvian tax equal to τ^*.

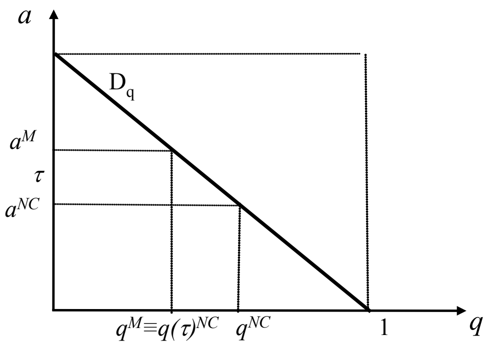

Figure 3.4.1: Demand for disposal of MW in monopoly and duopoly, and measure of the landfill tax

The analysis of Total Welfare is needed to compare the social desirability of the Pigouvian tax and of PP/SSP for any value of the environmental impact of disposing.

To deal with this issue, we consider the case of duopoly in the disposal market ($\alpha = 2/3$); then we calculate the difference between Total Welfare with the tax ($TW(\tau)^{NC}$) and with PP/SSP (TW^M), starting form the equation [3.4.3] and [3.4.4] introduced in the previous pages:

$$\Delta TW = TW(\tau)^{NC} - TW^M = \left(\bar{u} - e(\alpha) - k(\alpha)^2 - \phi q^*\right) - \left(\bar{u} - e^M - k^{M2} - \phi q^M\right) \qquad [3.4.11]$$

Where:

$$k(\alpha)^{NC} = \frac{2}{p}(1-\alpha) + \frac{p}{4}\alpha(\tau + \tilde{p} - p) \qquad [3.4.12]$$

$$e(\alpha)^{NC} = \frac{p^2}{8}\left[\frac{4\alpha}{p} + \frac{p}{2}\alpha(\tau + \tilde{p} - p)\right] \qquad [3.4.13]$$

Plugging [3.2.4], [3.2.5], [3.2.6], [3.4.5], [3.4.12], [3.4.13] in [3.4.11] and considering $\tau(\alpha = 2/3)$, we obtain:

$$\Delta TW = \frac{1}{64p^2}\left(p^2(\tilde{p} - 2\phi) + 8\right)^2 \qquad [3.4.14]$$

It is straightforward to see that [3.4.14] fall to zero for $\phi = \frac{4}{p^2} + \frac{\tilde{p}}{2}$, i.e. when q^* is the same of the case with PP/SSP (see equation [3.4.10]); in this case, there is no change in total welfare, and the only difference between the implementation of PP/SSP and the levying of a Pigouvian tax is in the transfer of the tax revenue τq^* from tax payers (Disposers) to tax renters (the Social Planner or the members of the local community).

But what is more relevant, for any other value of ϕ ΔTW is positive, and the Pigouvian tax is superior to PP/SSP in term of social welfare. This implies that, apart from the specific case captured by equation [3.4.10], the quantity of disposed MW is never optimal with PP/SSP, when ϕ is higher than the threshold represented by [3.4.10], because over-dimensioned ($q^M > q^*$), while the opposite happens when ϕ is under that threshold. In the first case, disposing is problematic from an environmental perspective and PP/SSP is a too small disincentive for it; in the second, disposing is not so impactful, and PP/SSP is too strict.

Remark 3.4.2

The optimal Pigouvian tax is more effective than PP/SSP in terms of total welfare for any value of the unit environmental cost of disposing, apart from a single value when they are equivalent.

In those countries where the landfill tax is implemented, it is usually charged to the Disposer, that usually passes it through to the agent who confers MW. It could be interesting to explore if a different tax-scheme would change the picture. For instance, a direct taxation of the Collector, the agent who actually decides the quota of MW to be addressed to landfill, could not end to a similar pass-through to its customer (the Local Council), because of the regulation of p.

Even in this case, the answer is negative: charging the tax directly to the Collector renders a different scenario, but with the same results. The main difference introduced with the latter scheme is that now the levy operates as a consumer tax, that reduces the demand for disposal service from the Collector. This means a shifting of demand curve downward (Figure 3.4.2).

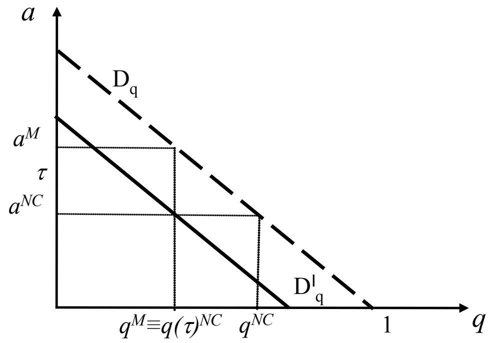

Figure 3.4.2: Demand for disposal of MW with tax on the Collector

The change of taxation scheme has an influence on the maximization structure, since now the Collector internalizes the tax payment in its objective-function. This means that his objective function becomes:

$$\Pi_C = (p - a - \tau)\left(1 - (ek)^{\frac{1}{2}}\right) + \tilde{p}(ek)^{\frac{1}{2}} - k^2 \qquad [3.4.15]$$

While the analogous objective function for the Local Council and the Disposers are the same as respectively [3.1.1] and [3.3.3]. Once the disposing industry is generalized to consider different available market organizations (i.e. leaving α undefinied), the Total Welfare function to be maximized by the Social Planner takes the following form:

$$\begin{aligned} &TW(\alpha) = U_{LC} + \Pi_C + \Pi_D(\alpha) - \tilde{p}(1 - q(\alpha)) + TR - \phi q(\alpha) = \\ &\bar{u} - pq(\alpha) - e(\alpha) + (p - a - \tau(\alpha))q(\alpha) + \tilde{p}(1 - q(\alpha)) - k(\alpha)^2 + aq(\alpha) - \tilde{p}(1 - q(\alpha)) + \tau(\alpha)q(\alpha) - \phi q(\alpha) \\ &= \left(\bar{u} - e(\alpha) - k(\alpha)^2 - \phi q(\alpha)\right) \end{aligned}$$

That is the same of [3.4.3]. As a consequence, the value of τ which solves the problem is the same of [3.4.4]: independently from the tax scheme implemented, the substitution of PP/SSP with an environmental tax are perfectly equivalent in terms of total welfare.

Remark 3.4.3

The implementation of a Pigouvian tax leads to the same result in terms of total welfare and tax revenue either when charged on the Disposers (i.e. a landfill tax) or on the Collector.

3.5 Spatial Formalization

In this Section we assume that, given that all other conditions unchanged, there are two bordering areas, each one with a Local Council, a monopolistic Collector and a disposing facility. Each Collector follows operating exclusively in their Area, but they have no obligation in disposing the picked undifferentiated waste in an assigned facility (F_A or F_B).

We capture the geographical aspects, a defining characteristic of this sector, through a simple model *à la* Hotelling (1929). Area A and B are represented as unit length lines, so that the overall market has a total length of 2 (see Figure 3.5.1). Households pertaining to a Local Council are uniformly distributed along the line in both areas, with $x_i \in [0; 2]$ denoting the location of a specific household. Disposal facilities are located at the extremes of each line, i.e. disposer A is located at $x = 0$, and disposer B at $x = 2$. Collectors face linear transportation costs in picking-up unsorted waste and bringing it to the location of the facilities.

We denote the total transport costs of gathering the waste and bringing it to the disposal facility as T_i.

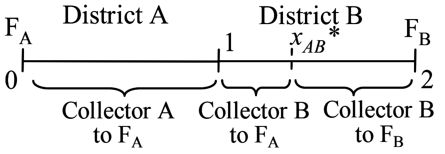

Figure 3.5.1: An example of deregulated spatial waste market.

3.5.1 Reshaping the Benchmark: Monopoly with Transportation Costs

In order to have a full comparison between monopoly and duopoly in a spatial setting, we must go back to the Monopoly case and introduce a variable that, up until now has been neglected; Collector's transportation cost to the (sole) domestic landfill.

Assuming the location of the autarchic landfill with monopoly is the same as the internal one with duopoly, and assuming that each household located along the linear town will produce the same quantity of waste, starting from [3.1.6] we must rewrite Collector's profit function as follows:

$$\Pi_C = (p-a)\left(1-(ek)^{\frac{1}{2}}\right)+\tilde{p}(ek)^{\frac{1}{2}}-k^2-tq\int_0^1 x\,dx$$

Whose reduced form is:

$$\Pi_C = \left(p-a-\frac{t}{2}\right)\left(1-(ek)^{\frac{1}{2}}\right)+\tilde{p}(ek)^{\frac{1}{2}}-k^2 \qquad [3.5.1]$$

Stage 1 (Local Council's optimization) remains identical, with the same effort at equilibrium described in [3.2.1].

In Stage 2, the Collector maximizes profit function [3.5.1] with respect to *k*; again, plugging [3.2.1] in, and rearranging, we obtain:

$$\max_{k} \Pi_C = \left(p - a - \frac{t}{2}\right)\left(1 - \frac{p}{2}k\right) + \tilde{p}\frac{p}{2}k - k^2$$

The first order condition is given by:

FOC:

$$\frac{\partial}{\partial k}\left(\left(p - a - \frac{t}{2}\right) - \left(p - \tilde{p} - a - \frac{t}{2}\right)\frac{p}{2}k - k^2\right) = \frac{p}{2}\left(\tilde{p} - p + a + \frac{t}{2}\right) - 2k = 0$$

which gives:

$$k^* = \frac{p}{4}\left(\tilde{p} - p + a + \frac{t}{2}\right) \qquad [3.5.2]$$

As expected, *k* is directly related to *t*: the higher the transportation costs to dispose unselected MW, the higher the Collector's interest in MW selection and, as a consequence, the higher the investment in selection capacity by him.

In Stage 3, The Disposer keeps on maximizing his profit function [3.1.8] according to [3.2.1], and [3.5.2], giving the following optimization problem:

$$a^M = \frac{4}{p^2} + \left(\frac{p - \tilde{p}}{2} - \frac{t}{4}\right) \qquad [3.5.3]$$

Compared with the non spatial case (see [3.2.3]), we observe that now the Disposer cuts the toll *a* by 25% of the transportation unit cost to be more competitive versus the rival activity of waste selection.

The corresponding quota of non-selected MW is:

$$q^M = \frac{1}{2}\left[1 - \frac{p^2}{8}\left(\tilde{p} - p + \frac{t}{2}\right)\right] \qquad [3.5.4]$$

Not surprisingly, even with the little rebate allowed by the Disposer, the new costs borne by the Collector to transfer waste to the landfill discourage disposing, and the total amount of undifferentiated waste at equilibrium is reduced with respect to the non-spatial specification [see 3.2.6].

3.5.2 Removing PP/SSP in a spatial framework

Going back to Figure 3.5.1 and taking for reference the collector operating in area A, collector A's profit can be written as:

$$\Pi^C{}_A = \begin{cases} (p_A - a_A)q_A x^*_{AB} + (p_A - a_B)q_A\left(1 - x^*_{AB}\right) + \tilde{p}_A d_A - k^2{}_A - T_A\left(x^*_{AB}\right) & \text{if} \quad x^*_{AB} < 1 \\ (p_A - a_A)q_A + \tilde{p}_A d_A - k^2{}_A - T_A\left(x^*_{AB}\right) & \text{if} \quad x^*_{AB} \geq 1 \end{cases} \qquad [3.5.5]$$

Where $x^*_{AB} < 1$ is the fraction of unsorted waste taken to the local disposer, whereas the rest is brought for disposal at the external facility; if $x^*_{AB} > 1$ the collector brings all unsorted waste to the local disposer. Clearly, under the current EU regulation, $x^*_{AB} = 1$ is enforced and it is not a variable of choice of the collector. As it will become clear, if regulation is lifted, x^*_{AB} will depend on the disposal prices at the two facilities and on the transport costs.

The total transport costs depend on x_i and can be expressed as:

$$T_A(x^*_{AB}) = \begin{cases} tq\left[\int_0^{x_{AB}} u\,du + \int_{x_{AB}}^{1} (2-u)\,du\right] & if \quad x^*_{AB} < 1 \\ tq\int_0^1 u\,du & if \quad x^*_{AB} \geq 1 \end{cases} \qquad [3.5.6]$$

and similar expressions hold for both the profits and transport costs of collector B.

The disposing facility D_i receives the unsorted MW and charges a_i for each unit to be disposed. Notice that a_i is the same, no matter what is the origin of the waste. If the PP/SSP is relaxed, in fact, the facility may receive waste from both the local and the outside collectors: the disposers are not allowed to discriminate waste according to its origin.

The profits of disposer A are, then:

$$\Pi^D{}_A(a_A, a_B) = \begin{cases} a_A[q_A + q_B(x^*_{AB} - 1)] & if \quad a_A < a_B \\ a_A q_A & if \quad a_A = a_B \\ a_A q_A x^*_{AB} & if \quad a_A > a_B \end{cases} \qquad [3.5.7]$$

and the profits of disposer B can be written in a similar way.

The timing of the game is as usual: at t, Disposers maximise $\Pi^D{}_i$ choosing the price a^*_i charged for the disposing service; At $(t+1)$ each Collector observes $a^*{}_i$ and maximises $\Pi^C{}_i$, choosing the quantity k^*_i of selection capacity to be provided to households; at $(t+2)$ each Local Council maximises U_{LC} choosing the effort e^*

Proceeding by backward induction, we start by solving for the LCs choices on the effort to be put into separated collection and the amount of unselected waste.

Stage 1 (Local Council optimization) does not change and it is the same in both areas, so that we can start from equation [3.2.1], rewritten as:

$$e_i^* = k_i \frac{p^2}{4}, \qquad i = A, B$$

which, in turn, implies that the unselected collection is:

$$q_i^* = 1 - \frac{k_i p_i}{2}, \; i = A, B \qquad [3.5.8]$$

Stage 2

Whereas the EU regulation constitutes the current *status quo*, it arises a special case in the model: hence, we shall first analyze the case of no regulation. If no regulation is imposed, from [3.2.1] and [3.5.8], it is immediate to find that:

$$x^*_{AB} = 1 + \frac{(a_B - a_A)}{2t} \qquad [3.5.9]$$

i.e. whether it is collector A or collector B to bring unsorted waste to the disposer in a different area depends on the price differential, $a_B - a_A$. If the latter is non-negative, then $x^*_{AB} > 1$. We can then start by assuming, without loss of generality, that $x^*_{AB} > 1$. Given [3.5.8] and [3.5.9], collectors maximize profits $\Pi^C{}_i$ with respect to k_i. The first order conditions are:

FOC:

$$\frac{\partial \Pi^C_A}{\partial k_A} = \frac{-8 p_A k_A^{\frac{3}{2}} + p_A^{\,2} k_A^{\frac{1}{2}} \left[2\left(a_A - p_A + \tilde{p}_A\right) + t\right]}{4 p_A k_A^{\frac{1}{2}}} = 0$$

$$\frac{\partial \Pi^C_B}{\partial k_B} = \frac{-16 t p_B k_B^{\frac{3}{2}} - p_B^{\,2} k_B^{\frac{1}{2}} \left[\left(a_B - a_A\right)^2 - 4t\left(a_B - p_B + \tilde{p}_B\right) - t^2\right]}{8 t p_B k_B^{\frac{1}{2}}} = 0 \qquad [3.5.10]$$

That gives the optimal selection capacity to be installed for separated collection[31]:

$$k^*_A = \frac{p_A}{8}\left[2\left(a_A - p_A + \tilde{p}_A\right) + t\right]$$

$$k^*_B = \frac{p_B}{8}\left[2\left(a_B - p_B + \tilde{p}_B\right) + t\right] - \frac{p_B}{16t}\left(a_B - a_A\right)^2 \qquad [3.5.11]$$

and, consequently, the resulting unsorted collection:

$$q^*_A = 1 - \frac{p_A^{\,2}}{16}\left[2\left(a_A - p_A + \tilde{p}_A\right) + t\right]$$

$$q^*_B = 1 - \frac{p_B^{\,2}}{32}\left[4\left(a_B - p_B + \tilde{p}_B\right) + 2t - \frac{\left(a_B - a_A\right)^2}{t}\right] \qquad [3.5.12]$$

Under the assumption $x^*_{AB} \geq 1$, Collector A brings all of the waste generated in area A to the local disposer. Hence, his selection capacity choice k^*_A is not directly affected by the price of disposing in area B. If the latter inequality is strictly satisfied, this is not the case for collector B. In absence of regulation and as the price of disposing in area A is lower than in B ($a_A < a_B$), then the waste of households located between 1 and x^*_{AB} is brought for disposal to area A. The rest of the waste, gathered between x^*_{AB} and 2, is disposed in area B. Clearly, then, the disposal price differential ($a_B - a_A$) affects the choices of collector B, as it can be seen in [3.5.11]. In particular, the higher the price of disposal in both areas, the higher is the incentive for the collector B to install selection capacity.

If the PP/SSP is imposed and $x^*_{AB} = 1$, the optimal selection capacity and unsorted collection are, respectively of disposal in both areas, the higher is the incentive for the collector B to install selection capacity are, respectively:

$$k^{EU}{}_i = \frac{p_i}{8}\left[2\left(a_i - p_i + \tilde{p}_i\right) + t\right] \qquad [3.5.13]$$

$$q^{EU}{}_i = 1 - \frac{p_i^{\,2}}{16}\left[2\left(a_i - p_i + \tilde{p}_i\right) + t\right] \qquad [3.5.14]$$

Comparing [3.5.11] and [3.5.13] it is clear that, for a given price of disposal a_A, the choice of collector A is not affected by the regulatory regime.

Stage 3

In absence of PP/SSP, the disposers maximize their profits given the choices of the Local Councils and of the Collectors. As we focus on the case $x^*_{AB} \geq 1$, the profits functions of the disposers are, respectively:

---

[31] It is immediate to verify that the second order conditions for a maximum hold.

$$\begin{aligned}\Pi^{D}{}_{A}(a_A, a_B) &= a_A\left[q_A x + q_B(1 - x_{AB})\right]\\ \Pi^{D}{}_{B}(a_A, a_B) &= a_B q_B(2 - x_{AB})\end{aligned} \qquad [3.5.15]$$

According to the previous assumption on x^*_{AB}, disposer A receives the unselected waste from both areas, whereas disposer B focuses on the remaining local waste.

In case PP/SSP is holding and $x^*_{AB} = 1$ is enforced, no waste can be transferred from one area to the other; as a consequence, the profit functions are:

$$\Pi^{D}{}_{i}(a_A, a_B) = a_i q^{EU}{}_{i} \qquad [3.5.16]$$

We can fully characterize the equilibrium if the PP/SSP principles hold. The following lemma highlights the disposers' price choices.

Lemma 3.5.1

The disposers' price choices in presence of the EU regulation are:

$$a^{EU}{}_{i} = \frac{1}{4}\left[\frac{16}{p_i^{2}} + 2p_i - 2\tilde{p}_i - t\right] \qquad [3.5.17]$$

Proof:

If EU regulation is in place, the first order conditions are symmetric for the two areas and can be written as:

$$FOC^{EU}{}_{i}(a_i) = q^{EU}{}_{i} + a_i\frac{\partial q^{EU}{}_{i}}{\partial a_i} = 0 \qquad [3.5.18]$$

Importantly, the first order condition is unaffected by the variables and parameters relating to area *j*. As $\partial q^{EU}{}_{i} / \partial a_i = -p_i^2/8$, then $FOC^{EU}{}_{i}(a_i)$ is decreasing in a_i and a unique equilibrium exists. Substituting the relevant expressions, the equilibrium can also be characterized as [3.5.17].

Q.E.D.

Lemma 3.5.1 shows that under regulation the disposers' price choices in each area are completely independent. In other words, EU regulation isolates local disposers from the competition of disposers from other areas.

The equilibrium price of disposal is affected by the parameters of the model in a complex way. First, $a^{EU}{}_{i}$ depends negatively on the unit revenue from separated collection, $\tilde{p}_i$, and on the transport cost, t. The price of disposal also depends non-monotonically on the price of unsorted collection: $a^{EU}{}_{i}$ increases if the collection price is sufficiently high. These effects depend on the way the parameters influence the collector's choice for selection capacity and how this, in turn, impacts on the demand for unsorted collection, $q^{EU}{}_{i}$ and, consequently, disposal.

We can then turn our attention to the effects of abandoning regulation and the PP/SSP principles. In this case we cannot fully characterize the equilibrium and provide the equilibrium expressions for the prices of disposal. However, the following results can be stated.

Proposition 3.5.1

(a) If in presence of the PP/SSP the equilibrium prices were identical, $a^{EU}{}_{A} = a^{EU}{}_{B}$, abandoning regulation leads to a decrease in the disposal prices a^*_i in both areas, $i = A, B$;

(b) if $a^{EU}{}_{A} < a^{EU}{}_{B}$, a sufficient condition for the disposal price of A to decrease if regulation is abandoned is: $a^{EU}{}_{A} > a^{EU}{}_{B}/2$. The disposal price of B decreases.

(c) If abandoning EU regulation leads to lower disposal prices, then the incentives to build capacity for separated collection, k^*_i, to exert effort e^*_i and, ultimately, the overall amount of separated collection as a whole, d^*_i are reduced.

Proof:

The effect of abandoning the current EU regulation is considered. Given our assumption on x^*_{AB}, there are two possible cases, depending on p_i and $\tilde{p}_i$: (a) the equilibrium is such that $a^{EU}{}_{A} = a^{EU}{}_{B}$; (b) the equilibrium is such that $a^{EU}{}_{A} < a^{EU}{}_{B}$.[32] We shall consider each in turn, corresponding to parts (a) and (b) of the Proposition.

(a) If $a^{EU}{}_{A} = a^{EU}{}_{B}$ and regulation stops being enforced, according to [3.5.9] we shall still have $x^*_{AB} = 1$. Suppose disposer A considers decreasing the price from $a^{EU}{}_{A}$; in that case the relevant profit function is [3.5.15], as $x^*_{AB} > 1$ following the considered price decrease. The impact of the change in the price, evaluated at $a^{EU}{}_{A} = a^{EU}{}_{B}$, can be written as:

$$\frac{\partial \Pi^D_A}{\partial a_A}\Big|_{a_A = a^{EU}_A} = \underbrace{FOC^{EU}_A\left(a^{EU}_A\right) + q^{EU}_B\left(x^*_{AB} - 1\right) + a^{EU}_A \frac{\partial q_B}{\partial a_A}\left(x^*_{AB} - 1\right)}_{=0} + \underbrace{a^{EU}_A q^{EU}_B \frac{\partial x^*_{AB}}{\partial a_A}}_{-} = 0 \qquad [3.5.19]$$

where the first three terms are zero as a consequence of $\partial \Pi^D{}_A / \partial a_A$ being evaluated at the EU equilibrium. Hence, [3.5.19] implies that a unilateral price decrease, increases disposer A profits. A similar argument applies to disposer B. These imply that $a^*_i < a^{EU}{}_{i}$.

(b) If $a^{EU}{}_{A} < a^{EU}{}_{B}$ then abandoning regulation would imply $x^*_{AB} > 1$ even if no price adjustment is made. From the perspective of disposer A, [3.5.15] is still the relevant profit function and the impact of a change in price is still:

$$\frac{\partial \Pi^D_A}{\partial a_A}\Big|_{a_A = a^{EU}_A} = \underbrace{FOC^{EU}_A\left(a^{EU}_A\right)}_{=0} + \underbrace{q^{EU}_B\left(x^*_{AB} - 1\right)}_{+} + \underbrace{a^{EU}_A \frac{\partial q_B}{\partial a_A}\left(x^*_{AB} - 1\right) + a^{EU}_A q^{EU}_B \frac{\partial x^*_{AB}}{\partial a_A}}_{-} = 0 \qquad [3.5.20]$$

In this case, however, the second term is positive as $x^*_{AB} > 1$, whereas the last two terms are negative. The sign of [3.5.20] then depends on:

$$\Phi = q^{EU}_B\left(x^*_{AB} - 1 + a^{EU}_A \frac{\partial x^*_{AB}}{\partial a_A}\right) + a^{EU}_A \frac{\partial q_B}{\partial a_A}\left(x^*_{AB} - 1\right) \qquad [3.5.21]$$

that, after substitution, can be re-written as:

$$\Phi = q^{EU}_B\left(\frac{1}{2t}\left(a^{EU}_B - 2a^{EU}_A\right)\right) - \frac{a^{EU}_A p^2{}_B}{32t^2}\left(a^{EU}_A - a^{EU}_B\right)^2 \qquad [3.5.22]$$

implying that $a^{EU}{}_{A} > a^{EU}{}_{B}/2$ is sufficient for $\Phi < 0$ and, as a consequence, $a^*_A < a^{EU}{}_{A}$.

From the point of view of disposer B abandoning regulation would imply a decrease in the demand ($2 - x^*_{AB} < 1$) even if no price adjustment is made. The relevant profits are [3.5.15] and the impact of a change in price, evaluated at the EU regulation equilibrium, can be written as:

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[32] Notice that if the equilibrium is such that $a^{EU}{}_{A} < a^{EU}{}_{B}$ and $x^*_{AB} < 1$, the proof follows from case (b) inverting the roles of A and B.

$$\frac{\partial \Pi_B^D}{\partial a_B}\Big|_{a_B=a_B^{EU}} = \underbrace{q_B^{EU}\left(2-x^*_{AB}\right)+a_B^{EU}\frac{\partial q_B}{\partial a_B}\left(2-x^*_{AB}\right)}_{FOC_B^{EU}\left(a_B^{EU}\right)}-\underbrace{a_B^{EU}q_B^{EU}\frac{\partial x^*_{AB}}{\partial a_B}}_{-}<0 \qquad [3.5.23]$$

The latter inequality holds as the first two terms are lower than the equivalent terms in [3.5.18] as ($2 - x^*_{AB} < 1$), whereas the last term is negative. As such, disposer B always reduces his price if regulation is lifted: $a^*_B < a^{EU}_B$.

(c) If abandoning regulation leads to a decrease in disposal prices a^*_i, then the results on selection capacity, effort and overall amount of separated collection follow directly from the results obtained at Stage 2 and 3. In particular, as $\partial k^*_i / \partial a^*_i > 0$ a lower disposal price implies a lower selection capacity; this, in turn, implies:

$$\frac{\partial e^*_i}{\partial k^*_i}\frac{\partial k^*_i}{\partial a^*_i}>0 \text{ and } \frac{\partial d^*_i}{\partial k^*_i}\frac{\partial k^*_i}{\partial a^*_i}>0$$

Q.E.D.

Proposition 3.5.1 states the main results of the exercise. In particular, part (a) and (b) identify the effects of relaxing the prescriptions of PP/SSP on waste collection and disposal.

Part (a) establishes that if two areas, regions or countries have very similar prices of disposal in the current *status quo*, opening the market for disposal and giving the possibility to collectors to transport waste to other neighbouring areas would lead to a reduction in the prices of disposal. The intuition is very simple: a small unilateral decrease in the price of disposal from $a^{EU}{}_{\mathrm{i}}$ would increase profits as it allows to extend the market size. In other words, the collector from the neighbouring area would consider bringing a small share of the waste, produced by households located near the border, to the disposal facility that reduced the price. As both disposers face this pressure to reduce prices, the resulting unregulated equilibrium features lower prices in both areas. Allowing disposal in other areas has a "pro-competitive effect" that decreases the cost of the disposal of unsorted waste in both areas.

Part (b) extends the result to the case in which areas are heterogeneous, which is reflected in a different price of disposal, $a^{EU}{}_{\mathrm{i}}$, in the regulated *status quo*. In particular, the result establishes that the pro-competitive effect of abandoning regulation is very likely to take place also in this case. A sufficient, but not necessary, condition for the price of disposal to decrease is that areas are not too heterogeneous and, more precisely, that the status-quo disposal prices are not too different. If, as we assumed, area A is characterized by a lower disposal price, the pro-competitive effect of abandoning PP/SSP prevails if the price is more than half of the price in area B. Moreover, the higher price disposer, for assumption $\mathrm{D_B}$, is surely going to decrease its price in response to deregulation.

Hence, unless areas are particularly heterogeneous, part (b) shows that it is very likely that the prices of disposing unsorted MW decrease when MW can travel across areas.

The intuition for this second result is more intricate. In particular, the effect of unilaterally decreasing the disposal price in area A, following a lift of the EU regulation can now be written as:

$$\frac{\partial \Pi_A^D}{\partial a_A}\Big|_{a_A=a_A^{EU}} = \underbrace{FOC_A^{EU}\left(a_A^{EU}\right)}_{=0}+\underbrace{a_A^{EU}q_B^{EU}\frac{\partial x^*_{AB}}{\partial a_A}}_{\text{pro-competitive effect}}+\underbrace{a_A^{EU}\frac{\partial q_B}{\partial a_A}\left(x^*_{AB}-1\right)}_{\text{Indirect effect on } q_B}+\underbrace{q_B^{EU}\left(x^*_{AB}-1\right)}_{\text{Infra-marginal gain}}=0 \qquad [3.5.24]$$

In [3.5.24] there are three new terms than in case EU regulation still holds. The usual "pro-competitive effect", identified in part (a), is now captured by the second term and it pushes down the disposal price of A. However, there are now two extra terms. The third term captures the negative relation between the unsorted waste in B, q_B, and the price of disposal a_A: as a share of waste is "exported" from B to A, a higher disposal price of A increases the average disposal cost in area B and that acts to decrease the household production of unsorted waste. This effect, that we shall call "indirect effect" on q_B, clearly goes in the same direction of the pro-competitive effect. The fourth term of [3.5.24], instead, captures the "infra-marginal gain" in profits due to abandoning regulation. This is related to the new market share obtained, as with no regulation $x^*_{AB} > 1$, and clearly encourages disposer A to increase its price. The complex balance of these three effects determines whether the price of disposal will decrease or not in area A: the condition provided on the prices of disposal establishes when the pro-competitive and indirect effects are surely dominating the infra-marginal gain. Matters are much simpler when looking at disposer B: in that case all the effects univocally point in the direction of a price decrease.

Finally, part (c) establishes the effects of a possible decrease in the price of disposing unsorted waste. Given the comparative statics obtained in the previous stages of the game it is simple to see that the pro-competitive effect identified at the disposal layer of the waste market has an important consequence: higher competition in disposal can reduce and hinder the amount of resources dedicated to separated waste (selection capacity and household effort), leading to an overall decrease of the separation achieved by the local communities.

3.5.3 A special case: symmetric areas

We now focus on the special case of symmetric areas. This case may be of particular interest when considering regions with similar characteristics and it has the further advantage that equilibria in both scenarios can be characterized.

Symmetry allows to consider $p_A = p_b = p$, and $\widetilde{p}_A = \widetilde{p}_B = \widetilde{p}$. The disposal equilibrium price under EU regulation is still:

$$a^{EU} = \frac{1}{4}\left[\frac{16}{p^2} + 2p - 2\widetilde{p} - t\right]$$

If regulation is lifted, instead, the disposers choose the equilibrium price:

$$a^* = \frac{1}{4}\left[\frac{16}{p^2} + 2p - 2\widetilde{p} + 7t\right] - \frac{\sqrt{4\left(p^3 - p^2\widetilde{p} + 8\right)^2 - 4p^2\left(p^3 - p^2\widetilde{p} + 8\right) + 65p^4t^2}}{4p^2} \qquad [3.5.25]$$

As a corollary of Proposition 3.5.1, the next result follows:

Corollary 3.5.1

If areas A and B are symmetric, abandoning EU regulation leads to a decrease in the prices of disposal: $a^* < a^{EU}$. The latter implies a reduction in the incentives to build capacity for selected collection k^*, to exert effort $e^*$and, ultimately, the overall amount of selected collection d^*.

Proof:

The claim follows directly from part (a) of Proposition 3.5.1. However, as the equilibrium is fully characterized, it is sufficient to compute the disposal price differential:

$$\Delta a = a^* - a^{EU} = 2t - \frac{\sqrt{4\left(p^3 - p^2\widetilde{p} + 8\right)^2 - 4p^2t\left(p^3 - p^2\widetilde{p} + 8\right) + 65p^4t^2}}{4p^2} \qquad [3.5.26]$$

For given p and $\tilde{p}$, it can be verified that the function $\Delta a(t)$ has only one zero, $\hat{t} = \frac{2}{p^2}\left(p^3 - p^2\tilde{p} + 8\right)$. Hence, for all other values of $t \neq \hat{t}$, $\Delta a(t)$ is either always positive or always negative. It is also straightforward to show that $\Delta a(t)$ is concave in t, as $\partial^2 \Delta a / \partial t^2 \leq 0$, implying that $\Delta a(t)$ is always negative for $t \neq \hat{t}$ and, consequently, $a^* < a^{EU}$. The implications of the result on selection capacity follow directly from part (c) of Proposition 3.5.1.

Q.E.D.

The corollary reinforces the message of Proposition 3.5.1. Relaxing the current EU regulation on waste management would make the disposer's segment of the market more competitive, with a decrease in the prices paid for disposal. However, the substitution between unsorted and separated collection lowers the collectors' incentives to invest in selection capacity. This, in turn, has a negative effect on the effort exerted by local councils and households, resulting in a lower and undesirable level of unsorted collection.

3.6 Removal of PP/SSP and Increase in MW Selection

In previous sections of Chapter 3 we show that PP/SSP fosters MW selection and discourage end-of-the-pipe diversion, and we advocate that this one is a sound reason for its enforcement by EU.

Nonetheless, in some circumstances a removal of PP/SSP and the implementation of MW free trade across districts is compatible with higher percentages of recycling. This happens whenever the perfect symmetry between different areas is not complied[33]. As we will see, this happens even when no shortage affects the supply of end-of-the-pipe capacity. In this Section we develop the intuition.

3.6.1 Regulated Disposal Price and Vertically Integrated Operators

For simplicity, we consider another benchmark situation, where there are two facilities operating and PP/SSP is enforced, but in each area Collector is merged with Disposer, to give birth to a vertically integrated MW management subject.

This means to reframe the model and introduce a new timing for it:

- at time $(t-1)$, a Vertically Integrated Operator is chosen as franchised or natural monopolist to operate in the collection market at the given unit price p; at the same $(t-1)$, the unit price $\tilde{p}$ for separate collection is set;
- At t, Vertically Integrated Operator observes a^* and maximises Π_C, choosing the quantity k^* of selection capacity to be provided to households;
- At $(t+1)$ Local Council maximises U_{LC} choosing the effort e^*.

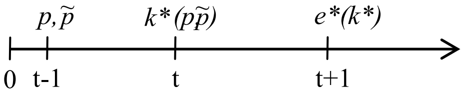

Figure 3.6.1 The timing of the model with PP/SSP and Vertically Integrated Operators

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[33] I owe this insight to Antonio Massarutto, Dept of Economics, University of Udine.

The objective function for the Vertically Integrated Operator providing both services of collection and disposing is now:

$$\Pi^{i}{}_{VI} = (p-c)q_i + \tilde{p}(1-q_i) - k_i^2 - tq_i\int_0^1 xdx$$

Putting the cost of disposing c equal to zero for simplicity, the reduced form of the previous equation is:

$$\Pi^{i}{}_{VI} = p\left(1-(ek_i)^{\frac{1}{2}}\right) + \tilde{p}(ek_i)^{\frac{1}{2}} - k_i^2 - \frac{t}{2}\left(1-(ek_i)^{\frac{1}{2}}\right), \qquad i = I,\ O \qquad [3.6.1]$$

Stage 1 (Local Council's optimization) remains identical, with the same effort at equilibrium described in [3.2.1].

In Stage 2, each the Vertically Integrated operator maximizes profit function [3.6.1] with respect to k; again, plugging [3.2.1] in, and rearranging, we obtain:

$$\max_{k_i}\Pi^{i}{}_{VI} = \left(p-\frac{t}{2}\right)\left(1-p\frac{k_i}{2}\right) + \tilde{p}p\frac{k_i}{2} - k_i^2 = \left(p-\frac{t}{2}\right) + \left(\tilde{p}-p+\frac{t}{2}\right)p\frac{k_i}{2} - k_i^2$$

The first order condition is given by:

FOC: $$\frac{\partial}{\partial k}\left(\left(p-\frac{t}{2}\right) + \left(\tilde{p}-p+\frac{t}{2}\right)p\frac{k_i}{2} - k_i^2\right) = \frac{p}{2}\left(\tilde{p}-p+\frac{t}{2}\right) - 2k_i = 0$$

which gives: $$k_i{}^* = \frac{p}{4}\left(\tilde{p}-p+\frac{t}{2}\right) \qquad [3.6.2]$$

Transportation cost keeps on acting as a deterrent to incinerate, but the "internalization" of the gate fee reduces the optimal investment in capital k at equilibrium.

The corresponding quota of unselected MW in each area is:

$$q_i{}^* = \left[1-\frac{p^2}{8}\left(\tilde{p}-p+\frac{t}{2}\right)\right] \qquad [3.6.3]$$

Meaning a total quantity of unselected waste given by:

$$q^* = q_I{}^* + q_O{}^* = 2\left[1-\frac{p^2}{8}\left(\tilde{p}-p+\frac{t}{2}\right)\right] \qquad [3.6.4]$$

Comparing [3.6.4] with the double value of [3.5.4] we get the evidence that vertical integration between WM operators fosters the generation of unselected MW and the recourse to end-of-the-pipe disposal.

3.6.2 Waste Trade

The first case we consider is when both districts can be served by the same Facility owned by the Vertically Integrated internal operator (results are the same when the Vertically Integrated operator in the external one).

In this way, a disparity is introduced in the benchmark framework, since Outside Collector is obliged to pay for the disposal service, while the Inside operator gets it for free, being a part of its own production process[34].

To make sure that the last one is the only source of discrepancy between internal and external operator, we assume that the internal facility is located exactly in the middle of the two-areas linear system, meaning that transportation costs are equal for both operators.

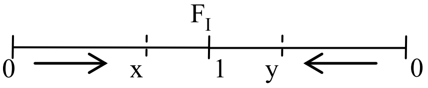

Figure 3.6.2. Removal of PP/SSP and transportation of MW to central facility FI

Finally, we assume that gate fee *a* charged to the Outside operator is not left to the market dynamics, but it is regulated by a planner. In this way, the optimization problem for the MW operator is similar in each area, and both firms maximize the profit choosing *k*.

The timing of the model changes as follows:

- at time $(t-1)$, a social planner set the unit prices p, $\tilde{p}$, and a;
- At *t*, MW operators observes the regulated prices and maximises Π_C, choosing the quantity k^* of selection capacity to be provided to households
- At $(t+1)$ Local Council maximises U_{LC} choosing the effort e^*.

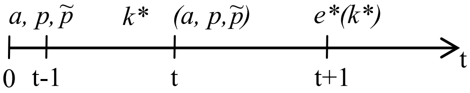

Figure 3.6.3 The timing of the model with regulated disposing service

Waste Trade with Capacity Unconstrained Facility

We assume that the facility, does not suffer from capacity constraint, meaning that the facility can always accept the whole amount of unsorted MW from both areas, even when q_i is maximum (i.e. equal to one).

Stage 1 (Local Council optimization) does not change with respect to the benchmark case illustrated in Section 1.3, rewritten in the form:

$$e_i^* = k_i \frac{p^2}{4}, \qquad i = I, O$$

Stage 2

In Stage 2, MW management operators maximizes the following profit functions with respect to *k*, but for the External one we must consider the existence of a new disposal cost (the fee *a*) that turns in a revenue for the Internal one. We consider p and $\tilde{p}$ identical for both areas:

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[34] The exercise works in the same way considering a given fee for the Internal Operator and an increased one for the External Operator. In this case, *a* has not to be considered as the full price charged to External Operator, but as the rise applied for him with respect to the fee charged to the Internal Operator.

$$\Pi^{O}{}_{C} = pq_O + \tilde{p}(1-q_O) - k_O{}^2 - \frac{tq_O}{2} - aq_O$$

$$\Pi^{I}{}_{VI} = pq_I + \tilde{p}(1-q_I) + aq_O - k_I{}^2 - \frac{tq_I}{2} \qquad [3.6.5]$$

The last one differing from [3.6.1] because of the presence of the revenue from the disposing service provided to the Outside Collector. Plugging [3.2.1] in, and rearranging, we obtain:

$$\max_{k_O} \Pi^{O}{}_{C} = \left(p - a - \frac{t}{2}\right) + \left(\tilde{p} - p + a + \frac{t}{2}\right)\frac{p}{2}k_O - k_O{}^2, \text{ and}$$

$$\max_{k_I} \Pi^{I}{}_{VI} = \left(p - \tilde{p} - \frac{t}{2}\right)\left(1 - \frac{p}{2}k_I\right) + \tilde{p} + a_O q_O - k_I{}^2$$

The first order condition for the MW management operators are given by:

FOC:

$$\frac{\partial}{\partial k_O}\left(\left(p - a - \frac{t}{2}\right) + \left(\tilde{p} - p + a + \frac{t}{2}\right)\frac{p}{2}k_O - k_O{}^2\right) = \frac{p}{2}\left(\tilde{p} - p + \frac{t}{2}\right) - 2k_O = 0, \qquad \text{and}$$

$$\frac{\partial}{\partial k_I}\left(\left(p - \tilde{p} - \frac{t}{2}\right)\left(1 - \frac{p}{2}k_I\right) + \tilde{p} + a_O q_O - k_I{}^2\right) = \frac{p}{2}\left(\tilde{p} - p + \frac{t}{2}\right) - 2k_I = 0$$

which gives:

$$k_O{}^* = \frac{p}{4}\left(\tilde{p} - p + a + \frac{t}{2}\right), \text{ and}$$

$$k_I{}^* = \frac{p}{4}\left(\tilde{p} - p + \frac{t}{2}\right)$$

The corresponding quota of unselected MW in each area is:

$$q_O{}^* = \left[1 - \frac{p^2}{8}\left(\tilde{p} - p + a + \frac{t}{2}\right)\right] \qquad [3.6.6]$$

$$q_I{}^* = \left[1 - \frac{p^2}{8}\left(\tilde{p} - p + \frac{t}{2}\right)\right]$$

Meaning a total quantity of unselected waste given by:

$$q^* = q_I{}^* + q_O{}^* = 2\left[1 - \frac{p^2}{8}\left(\tilde{p} - p + \frac{t}{2}\right)\right] - a\frac{p^2}{8} \qquad [3.6.7]$$

The result of the elimination of the external facility is evident: while it does not affect the decision on the quota of recycling achieved by the Inside operator (the owner of the facility), it forces Outside operator to reduce disposal by $ap^2/8$, so that the total amount of unsorted MW generated in the two-areas system is lower than the benchmark outcome [3.6.4] for the same value.

Remark 3.6.1

In a framework with a vertically integrated MW operator and regulated price of disposal, the removal of PP/SSP conjoint with the allowance of a single unconstrained facility, fosters the generation of selected MW with respect to the same case where two symmetric facilities operate.

Waste Trade with Capacity Constrained Facility

The previous scenario changes if the same facility is affected by capacity constraint, so that the service for the external operator is available just after the "pre-emption" of the internal one is acquitted.

To consider this new assumption, we introduce in the model a capacity constraint $\overline{H}$ for the facility, which affects the generation of unsorted MW by the external area as follows:

$$q_O = \overline{H} - q_I \qquad [3.6.8]$$

While the profit function for the external operator is still illustrated by [3.6.6], and the maximization problem does not change from the one developed in previous section, equation [3.6.8] modifies the picture for the internal operator, whose profit function becomes:

$$\Pi^I{}_{VI} = pq_I + \tilde{p}(1-q_I) + a\left(\overline{H} - q_I\right) - k_I{}^2 - \frac{tq_I}{2} \qquad [3.6.9]$$

And the maximization problem is:

FOC: $$\frac{\partial}{\partial k_I}\left(pq_I + \tilde{p}(1-q_I) + a\left(\overline{H} - q_I\right) - k_I{}^2 - \frac{tq_I}{2}\right) = \frac{p}{2}\left(\tilde{p} - p - a + \frac{t}{2}\right) - 2k_I = 0$$

which gives: $$k_I{}^* = \frac{p}{4}\left(\tilde{p} - p - a + \frac{t}{2}\right)$$

The corresponding quota of unselected MW in the internal area is:

$$q_I{}^* = \left[1 - \frac{p^2}{8}\left(\tilde{p} - p + a + \frac{t}{2}\right)\right] = q_O{}^*$$

This is a very relevant result, that allows to see that the optimal behaviour of the internal operator is equal to external's one: as a matter of fact, with capacity constraint the internal operator maximizes his profit reducing the generation of unsorted waste, and using part of facility's capacity to treat the unsorted waste generated by the external operator.

As a consequence, the total amount of unsorted waste is:

$$q^* = q_I{}^* + q_O{}^* = 2\left[1 - \frac{p^2}{8}\left(\tilde{p} - p + a + \frac{t}{2}\right)\right] \qquad [3.6.10]$$

This is lower than the same total amount q^* in both previous cases (see Section 3.6.2) and, what is more relevant, the benchmark case [3.6.4].

Remark 3.6.2

In a framework with a Vertically Integrated MW operator and regulated price of disposal, the removal of PP/SSP conjoint with the allowance of a single constrained facility, fosters the generation of selected MW with respect to the same case where two symmetric facilities operate and even with respect to the single facility unconstrained case.

3.6.3 MW Selection Ability and Effectiveness in the Location of the Facility

Another potential source of disparity between the two areas is given when one community is more effective in generating selected MW, either because of a deeper commitment in the issue by inhabitants or due to a better technology supplied by the Collector.

We assume that the internal community is more able than the external one in selecting MW (the symmetric outcome will be obtained with mirroring assumption), leaving apart any explication on the source of this discrepancy. This implies to consider two different MW selection production functions, one for each Area:

$$d_O = (ek)^{\frac{1}{2}}$$

$$d_I = \alpha(ek)^{\frac{1}{2}}\text{, with } \alpha > 1 \qquad [3.6.11]$$

As we can see, with the same level of effort or investment in selection capacity, the internal community produces a higher amount of selected waste.

We confirm the framework where MW operators are vertically integrated in both districts. This means that the backward induction solution for the external area leads again to [3.6.2] and [3.6.3], while for the internal area the results are the following:

In step 1, the maximization problem of the Local Council is given by:

$$U^I{}_{LC} = \bar{u} - pq_I - e = \bar{u} - p\left(1-\alpha(ek)^{\frac{1}{2}}\right) - e$$

With first order condition:

FOC: $$\frac{\partial}{\partial e}\left(\bar{u} - p\left(1-\alpha(ek)^{\frac{1}{2}}\right) - e\right) = 0$$

And optimal effort: $$e_I{}^* = k_I\alpha^2\frac{p^2}{4} \qquad [3.6.12]$$

In step 2, the Vertically Integrated operator maximizes [3.6.1] plugging [3.2.1] in:

$$\max_{k_I}\Pi^I{}_{VI} = \left(p-\frac{t}{2}\right)\left(1-p\alpha^2\frac{k_I}{2}\right)+\tilde{p}\alpha\frac{k_I}{2}-k_I{}^2 = \left(p-\frac{t}{2}\right)+\left(\tilde{p}-p+\frac{t}{2}\right)\alpha\frac{k_I}{2}-k_I{}^2$$

The first order condition is given by:

FOC: $$\frac{\partial}{\partial k}\left(\left(p-\frac{t}{2}\right)+\left(\tilde{p}-p+\frac{t}{2}\right)\alpha p\frac{k_I}{2}-k_I{}^2\right) = \alpha\frac{p}{2}\left(\tilde{p}-p+\frac{t}{2}\right)-2k_I = 0$$

which gives: $$k_I{}^* = \alpha\frac{p}{4}\left(\tilde{p}-p+\frac{t}{2}\right) \qquad [3.6.13]$$

The corresponding quota of unselected MW is:

$$q_I^* = \left[1 - \alpha^2 \frac{p^2}{8}\left(\tilde{p} - p + \frac{t}{2}\right)\right] \qquad [3.6.14]$$

For a total quantity of unselected waste given by:

$$q^* = q_I^* + q_O^* = 2 - \frac{p^2}{8}\left(\tilde{p} - p + \frac{t}{2}\right)\left(1 + \alpha^2\right) \qquad [3.6.15]$$

Since $\alpha > 1$, [3.6.15] is lower than [3.6.4]: the higher ability in selection of one community allows the system as a whole to generate a reduced level of unsorted MW.

In a case where an exogenous factor affects the final result of the interaction among agents, the research question on the opportunity to remove PP/SSP is enhanced by a second issue, given by the ownership of the allowed facility that maximizes the production of selected MW with respect to the benchmark.

Effectiveness with Capacity Unconstrained Facility

We impose the operation of a single disposing facility, with services available to internal and external MW operators. We assume that the facility can treat all the MW operators bestow, since there is no capacity constraint.

The objective is to understand if the removal of PP/SSP would entail a reduction in unsorted MW and, if so, whether this reduction would be higher when the disposal facility is run by the operator working in the more efficient area in terms of selection ability or, on the contrary, in the less efficient one.

If the internal operator run the facility, the maximization problem for him is the one drawn in the benchmark; as a consequence, the production of unselected MW in the internal area is the same illustrated in function [3.6.14], namely:

$$q_I^* = \left[1 - \alpha^2 \frac{p^2}{8}\left(\tilde{p} - p + \frac{t}{2}\right)\right]$$

The external operator is obliged to pay the gate fee *a* for the service of disposing, so that his maximization problem is equal to the one developed in Section 2.1, with an unselected MW level at equilibrium given by [3.6.6]:

$$q_O^* = \left[1 - \frac{p^2}{8}\left(\tilde{p} - p + a + \frac{t}{2}\right)\right]$$

This means a total amount of unsorted MW equal to:

$$q^* = q_I^* + q_O^* = \left[2 - \frac{p^2}{8}\left(\tilde{p} - p + \frac{t}{2}\right)\left(1 + \alpha^2\right)\right] - a\frac{p^2}{8} \qquad [3.6.16]$$

Comparing [3.6.16] with the benchmark value [3.6.15], we can observe an actual reduction in the percentage of unsorted MW, equal to $ap^2/8$.

On the other hand, if the facility is owned by the external operator, the picture changes: now, the maximization problem of the Outside Vertically Integrated operator is the same as in the benchmark, and the external area level of unsorted MW equal to [3.6.3]:

$$q_O* = \left[1 - \frac{p^2}{8}\left(\tilde{p} - p + \frac{t}{2}\right)\right]$$

While the internal operator ought to pay for the disposal service, so that his maximization problem becomes:

$$\max_{k_I} \Pi^I{}_C = (p-a)\left(1-\alpha(ek_I)^{\frac{1}{2}}\right) + \tilde{p}\alpha(ek_I)^{\frac{1}{2}} - k_I{}^2 - \frac{t}{2}\left(1-\alpha(ek_I)^{\frac{1}{2}}\right), \text{ with}$$

$$e_I = k_I \frac{\alpha^2 p^2}{4}$$

The solution is:

$$k_I = \alpha \frac{p}{4}\left(\tilde{p} - p + a + \frac{t}{2}\right) \qquad [3.6.17]$$

Leading to a quota of unsorted MW in the internal area equal to:

$$q_I* = \left[1 - \alpha^2 \frac{p^2}{8}\left(\tilde{p} - p + a + \frac{t}{2}\right)\right] \qquad [3.6.18]$$

And to a total amount equal to

$$q* = q_I* + q_O* = \left[2 - \frac{p^2}{8}\left(\tilde{p} - p + \frac{t}{2}\right)\left(1+\alpha^2\right)\right] - a\frac{\alpha^2 p^2}{8} \qquad [3.6.19]$$

Again, being $\alpha > 1$, [3.6.19] is lower not only than the total amount $q*$ in the benchmark case [3.6.15], but even of the same $q*$ when the facility is operating in the more efficient district [3.6.16]. As a matter of fact, once forced to pay for the disposal service, the internal area increase the recourse to selection and, being very effective in this activity, the final outcome is more satisfactory than in the symmetric case, i.e. when the same effort is requested to the less effective community.

Remark 3.6.3

In a framework with Vertically Integrated MW operators and regulated price of disposing, with an asymmetry in the communities' ability in selecting MW, the removal of PP/SSP and the allowance of a single unconstrained facility fosters the generation of selected MW with respect to the same case where two symmetric facilities operate. In this case, the higher reduction in unsorted MW is achievable when the facility is run by the Vertically Integrated firm operating in the less able area in terms of MW selection.

Effectiveness with Capacity Constrained Facility

In this Section we propose the same exercise of the previous one with the assumption that the facility is capacity constrained, so that the Collector can just fill the facility's slots left empty by the Vertically Integrated operator.

Again, first we want to verify if the removal of PP/SSP leads to a higher total MW, and then we search for the best facility location in terms of reduction of the total unselected MW.

Assuming that the Vertically Integrated subject is the firm operating in the internal area, the external operator ought to pay for the service. Its demand for disposing is not affected by the facility's capacity constraint, and it is the same observed in [3.6.6]:

$$q_O{}^* = \left[1 - \frac{p^2}{8}\left(\tilde{p} - p + a + \frac{t}{2}\right)\right]$$

The introduction of the capacity constraint in the optimization problem of the Vertically Integrated Operator follows the line of the previous Section, with a profit function that embeds [3.6.6], being equal to:

$$\Pi^I{}_{VI} = pq_I + \tilde{p}(1 - q_I) + a\left(\overline{H} - q_I\right) - k_I{}^2 - \frac{tq_I}{2}, \text{ and}$$

$$q_I = 1 - \alpha^2 \frac{p}{2} k_I$$

So that the maximization problem becomes:

FOC: $\frac{\partial}{\partial k_I}\left(\left(p + a\overline{H}\right) + \left(p - \tilde{p} - \frac{t}{2} - a\right)\left(1 - \alpha \frac{p}{2} k_I\right) - k_I{}^2\right) = -\alpha \frac{p}{2}\left(p - \tilde{p} - a - \frac{t}{2}\right) - 2k_I = 0$

which gives: $k_I{}^* = \alpha \frac{p}{4}\left(\tilde{p} - p + a + \frac{t}{2}\right)$

The corresponding quota of unselected MW in the internal area is the same as [3.6.17], which added to q_O, gives the total result of:

$$q^* = q_I{}^* + q_O{}^* = \left[2 - \frac{p^2}{8}\left(\tilde{p} - p + a + \frac{t}{2}\right)\left(1 + \alpha^2\right)\right] \qquad [3.6.20]$$

Once more, the result is lower than the benchmark for a value equal to $\frac{ap^2}{8}\left(1 + \alpha^2\right) > 0$.

In addiction, we can observe that [3.6.20] is even lower than [3.6.19] for a value equal to $ap^2/8 > 0$, i.e. the constraint forces the internal operator to reduce the recourse to the disposal facility and to sell the left capacity to the external Collector at gate fee *a*.

The last analysis regards the opportunity to put the constrained facility under control of the external operator, that turns in the Vertically Integrated one.

In this case, the demand for disposal of the Internal Collector is the same as [3.6.18], while the optimization problem for the Outside Vertically Integrated firm is:

$$\Pi^O{}_{VI} = pq_O + \tilde{p}(1 - q_O) + a\left(\overline{H} - q_O\right) - k_O{}^2 - \frac{tq_O}{2}, \text{ and}$$

It is the same maximization problem illustrated in [3.6.9], with a solution that implies a quota of unselected MW equivalent to [3.6.10]:

$$q_O{*} = \left[1 - \frac{p^2}{8}\left(\tilde{p} - p + a + \frac{t}{2}\right)\right]$$

This rise the total demand for disposal satisfied by the facility at:

$$q{*} = q_I{*} + q_O{*} = \left[2 - \frac{p^2}{8}\left(\tilde{p} - p + a + \frac{t}{2}\right)\left(1 + \alpha^2\right)\right]$$

It is easy to see that the last result is equivalent to [3.6.20], so that the same remarks apply: the value of $q*$ is higher than the benchmark case, demonstrating once again that the removal of PP/SSP enhances the percentage of MW selection at equilibrium in the whole system made of the two linear areas. As in the previous section, the constraint of the single operating facility reduces the amount of unsorted MW to the minimum value, even if the obtained result is not lower than the value found when the unconstrained facility is run by an external Vertically Integrated Operator.

Remark 3.6.4

In a framework with a Vertically Integrated MW operator and regulated price of disposing, with an asymmetry in the communities' ability in selecting MW, the removal of PP/SSP and the allowance of a single constrained facility fosters the generation of selected MW with respect to the same case where two symmetric facilities operate. Contrary to the unconstrained case, the final result is the same for any location of the Vertically Integrated MW operator.

3.6.4 Waste trade with Market Disposal Price

In previous case we considered prices (p, $\tilde{p}$ and a) regulated by a public planner. This is not the standard assumption we used in former pages, where the gate fee a arises from the optimization problem of an independent Disposer.

It is worth asking if in such a framework there a total unsorted MW reduction when free MW trade is allowed, i.e. when the PP/SSP is removed, is still available.

The answer to the question is positive just when the only operating facility is located at the extreme of the linear interval (see Figure 3.6.4); otherwise, due to the fact that the unconstrained Disposers charges the same price to both Collectors, the solution is identical to the benchmark proposed in Section 3.5.1. A facility located in F$_I$ introduces in the model a discrepancy given by different transportation costs between Inside and Outside Collectors.

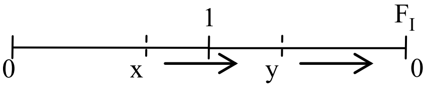

Figure 3.6.4. Removal of PP/SSP and transportation of MW to peripheral facility FI

In first two stages of the backward induction problem, the only change with respect to the mentioned benchmark is given by the profit function of the external Collector, that becomes:

$$\Pi^O{}_C = (p - a)q_O + \tilde{p}(1 - q_O) - k_O{}^2 - tq\int_0^1 (2 - x)dx =$$

$$\Pi^O{}_C = \ldots = \tilde{p} + \left(\tilde{p} - p - a - \frac{3}{2}t\right)\left(1 - \frac{p}{2}k_O\right) - k_O{}^2 \qquad [3.6.21]$$

The first order condition is given by:

FOC: $$\frac{\partial}{\partial k}\left(\tilde{p}+\left(\tilde{p}-p-a-\frac{3}{2}t\right)\left(1-\frac{p}{2}k_O\right)-k_O{}^2\right)=\frac{p}{2}\left(\tilde{p}-p+a+\frac{3}{2}t\right)-2k=0$$

which gives: $$k_O{}^*=\frac{p}{4}\left(\tilde{p}-p+a+\frac{3}{2}t\right) \qquad [3.6.22]$$

The corresponding MW to be disposed in the external area is:

$$q_O{}^*=\left[1-\frac{p^2}{8}\left(\tilde{p}-p+a+\frac{3}{2}t\right)\right] \qquad [3.6.23]$$

While in the internal one is confirmed the amount of q_I identified in the benchmark case, for a total demand for disposal services given by:

$$q^*=q_I{}^*+q_O{}^*=2\left[1-\frac{p^2}{8}\left(\tilde{p}-p+a+t\right)\right] \qquad [3.6.24]$$

In Stage 3, the individual Disposer optimizes the usual profit function [3.1.8], but with q given by the previous [3.6.24], i.e.:

$$\max_a \Pi_D=a\left(1-\frac{p^2}{8}\left(\tilde{p}-p+a+t\right)\right)$$

The first order condition is:

FOC: $$\frac{\partial}{\partial a}\left(a\left(1-\frac{p^2}{8}\left(\tilde{p}-p+a+t\right)\right)\right)=0$$

And the solution is:

$$a^*=\frac{4}{p^2}+\left(\frac{p-\tilde{p}-t}{2}\right) \qquad [3.6.25]$$

Plugging [3.6.25] back into [3.6.24], we get the total amount of unsorted MW generated in the two-areas system at equilibrium, namely:

$$q^*=q_I{}^*+q_O{}^*=1-\frac{p^2}{8}\left(\tilde{p}-p+t\right) \qquad [3.6.26]$$

With respect to the benchmark double value [3.5.4], we can see that unsorted MW decreases of a quantity equal to $tp^2/16$: the Disposer cuts the gate fee to compensate the lower demand from the external area due to the rise in transportation costs; this fosters a demand from Internal area that is higher than in the benchmark case, but insufficient to substitute the collapse in the external demand caused by the positioning away of the facility. As a consequence, the final effect is the mentioned reduction in the production of unsorted MW.

Remark 3.6.5

In a framework with independent Collectors and Disposers, the removal of PP/SSP conjoint with the allowance of a single unconstrained facility positioned at the extreme of a linear two-areas system, fosters the generation of selected MW with respect to the same case where two symmetric facilities operate; the latter case is equivalent to a situation with a sole operating facility placed in the middle of the two-areas system interval.

Chapter 4:
An Empirical Insight in MW Industry: Evidence from Lombardy

In the previous Chapter we claimed that the percentage of MW selected or diverted in a end-of-the-pipe facility is strictly related to market variables, namely the unit cost of diversion p and the unit revenue from selection $\widetilde{p}$, and the degree of openness of the diversion market.

In this Chapter we estimate the correspondence of the model to empirical data. To do so, we use a data base built up by us, starting from the data of the Waste Management Plan of Regional Government of Lombardy (Italy), published in 2012[35].

Besides of the accuracy and the topicality of published information, the choice of region Lombardy is motivated by other reflections: the size of the universe of observation (1.544 municipalities, the highest number for an Italian region), the relevance of the territory for Italy (region with the highest resident population, and with the highest revenue per-capita), and the long-run practice in the MW management issue (fifth region in Italy for the percentage of selected MW, one out of the seven able to fit the EU objective of 45% of selection by 2010; location for the most prominent multi-utility firm in Italy, one of the biggest in Europe).

We considered 1.522 municipalities of Lombardy (see Par. 4.1), dropping out 22 of them due to lack of relevant data[36].

The estimation of the model developed in Chapter 3 gives some puzzling evidence (see Par. 4.2). For this reason, we have searched for new factors to explain the main drivers for MW selection (see Par. 4.3), finding evidences that belong to physical, socio-economic and political fields.

The discussion of the results frequently describes for stylistic reasons the effect of independent variables on a dependent variable. Indeed, given the cross-sectional nature of our data, no exogenous variation is present that would allow a causal interpretation of our results, and our analysis has to be interpreted as the search for robust *ceteris paribus* correlations or statistical associations between variables.

4.1 The Data set

The data set is made of 1,522 observations (the number of municipalities) per two complementary dependent variables (alternatively the quota of selected and of unselected waste) and 17 independent variables: three of them belong to the "theoretical model" field and are used to estimate the fitting of the prominent equations we developed in Chapter 3; three of them belong to the structural (or physical/geographical) field; five are socio-economic variables; five are political. The following table describes each variable used in the estimations:

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[35] Regione Lombardia, ARPA Lombardia, Finlombarda, Ars Ambiente Srl, ERSAF Lombardia, Politecnico di Milano, 2013, *Programma regionale di gestione dei rifiuti comprensivo del programma regionale di bonifica delle aree inquinate*, downloaded from www.reti.regione.lombardia.it.

[36] The missing municipalities are: Borgo di Terzo, Luzzana, Vigano (Province of Bergamo); Cabiate, Cavallasca, Cerano d'Intelvi, Dosso del Liro, Pigra, San Fermo della Battaglia (Province of Como), Abbadia Cerreto, Corte Palasio (Province of Lodi), Torre Berretti e Castellaro (Province of Pavia), Caspaggio, Cedrasco, Chiese in Valmalocco, Lanzade, Pedesino, Spriana, Torre di Santa Maria (Province of Sondrio).

Field	Name	Description	Unit of measure	Year	Source	Min	Max	Mean
Dependent variable	*d*	Quota of total MW selected	Percentage	2012	Lombardy Regional Waste Mngm. Plan	0.057	0.871	0.524
	q	Quota of total MW unselected (opposite to the previous)	Percentage	2012	Lombardy Regional Waste Mngm. Plan	0.129	0.943	0.475
Theoretical model	*k*	Number of different MW categories collected	Absolute value (no. of units)	2012	Lombardy Regional Waste Mngm. Plan	1	22	13.77
	p_{tot}	Cost of total management (collection, selection, diversion) per kilogram of MW	Index (€/kg)	2012	Lombardy Regional Waste Mngm. Plan	0.104	0.818	0.268
	e	Turnout at 2013 national elections	Percentage	2013	Italian Ministry of Interior	0.496	1	0.796
Physical/ geographical	*dens*	Demographic density in the municipality	Index (Inhab/km$^{2)}$	2012	ISTAT + Municipal Registry offices	3.0	115,072	417.9
	height	Altitude above the sea level	Absolute value (m)	2001	ISTAT Italian Census	11	1,816	277.04
	dist	Linear distance between the municipality (Town Hall) and the municipality of the assigned disposal facility	Absolute value (km)	2014	Our calculation on Lombardy Regional Waste management Plan data	1.35	84.46	26.27
Socio-economic	*school*	Quota of graduated inhabitants out of 18 years old and more inhabitants	Percentage	2001	ISTAT Italian Census	5.68	70.69	32.8
	wage	Per capita wage of population	Average value (€ per capita)	2011	Italian Revenue Agency	2,077	32,859	15,502
	inhab_fam	Average number of people per household (total population over number of households)	Average value (no. of units)	2012	ISTAT + Municipal Registry offices	1.42	3.01	2.22
	age	Average age of inhabitants	Average value (years)	2012	ISTAT + Municipal Registry offices	33.9	60.4	43.9
	house	Average real estate value per square meter	Average value (€/sqm)	2012	Italian Territory Agency	525	4,900	1,108
Political	*gov_6*	Political affiliation of the Major in a scale 1-6: 1 = Lega Nord; 2 = PdL-Lega Nord; 3 = Civic list (Right); 4 = Civic List (Apolitical); 5 = Civic list (Left); 6 = PD and allies	Scale 1-6	2012	Italian Ministry of Interior			
	gov_3	Political affiliation of the Major in a scale 1-3: 1 = Right; 2 = Civic List (Apolitical); 3 = Left	Scale 1-3	2012	Italian Ministry of Interior			
	gov_2	Political affiliation of the Major in a scale 0-1: 0 = Civic list; 1 = Political alliance	Dummy 0-1	2012	Italian Ministry of Interior			
	cont	Political continuity or discontinuity of the ruling Major with predecessor	Dummy 0-1	2012	Italian Ministry of Interior + research on local press			
	tia	Enforcement of a waste tariff in place of a general tax	Dummy 0-1	2012	Lombardy Regional Waste Mngm. Plan			

Table 4.1.1 Description of variables in the data set

The previous list of variables claims for a further explication:

d and *q* are the standard dependent variables of the model introduced in Chapter 3; we express them in terms of percentage (in a zero-one scale) of the whole amount of MW generated and collected in the municipality.

k, p_{tot} and e are the independent variables of the mentioned model. We express k (an indicator of the size of the differentiated collection capacity provided by the Collector, see Par. 3.1) as the number of different MW categories collected in each municipality (such as organic, paper and cardboard, glass, plastic, iron, aluminium, wood, green, electrical/electronic devices, clothes and canvases, oils, and so on). The rationale of this choice is that any different category claims for a specific organization of the collection chain, and the higher the number of categories, the more sophisticated – and costly – the provision of the equipment to deal with them.

p_{tot} is the cost of total management per kilogram of MW paid by the municipality, considering the whole MW chain (collection, selection, diversion in and end-of-the-pipe facility). This means that the proxy we use in the estimation integers both p and $\widetilde{p}$, in a way that is impossible to disentangle.

e is the turnout at the National Elections of march 2013, the closest to the year of data survey in which all inhabitants of the whole group of municipalities have been simultaneously convened to vote. Since we can consider it an indicator of the social capital of the population, according to a wide literature on regional studies (D'Amato *et al.*, 2011), we use it as a proxy of the effort of local council in selection.

Apart from the variables introduced in the model, we consider a set of regressors of different kinds: physical, socio-economic, and political characteristics.

Among the physical variables, *dens* and *height* are standard items provided by the Italian national board of statistics (ISTAT), regarding respectively the demographic density (number of inhabitants over the area of the municipality) and the altitude from the sea level calculated in the place where the municipal Town Hall is located. A more sophisticated variable is *dist*, that is the linear distance from each municipality to the municipality where is located the disposal facility (landfill, incinerator or pre-treatment plant) associated to the initial municipality by the Lombardy Regional Waste management Plan. The rationale of employing this variable is straightforward: we want to study if the distance and the related travel costs to be borne to transport unselected MW to the assigned disposal facility are a motivation for higher rates of selection.

The disposal facilities considered to calculate the distance are the following (the linear distance is computed between the town halls of the two municipalities):

Facility	Municipality	Reference Area
Incinerator REA	Dalmine (BG)	Whole province of Bergamo + whole province of Sondrio
Incinerator Aprica A2A	Brescia (BS)	Whole province of Brescia
Pre-treatment plant Econord	Como (CO)	126 municipalities in province of Como
Landfill Econord	Mozzate (CO)	6 municipalities in province of Como
Incinerator AEM	Cremona (CR)	Whole province of Cremona
Incinerator Silea	Lecco (LC)	Whole province of Lecco
Pre-treatment Plant Belissolina	Montanaso Lombrado (LO)	Whole province of Lodi
Incinerator Prina Ltd	Trezzo sull'Adda (MI)	Whole province of Monza and Brianza
Incinerator AMSA	Milan (MI)	Whole province of Milan
Pre-treatment plant Mantova Ambiente	Ceresara (MN)	Whole province of Mantua
Incinerator Lomellina Energia	Parona (PV)	Whole province of Pavia
Incinerator ACCAM	Busto Arsizio (VA)	116 municipalities in the province of Varese
Landfill Econord	Gorla Maggiore (VA)	24 municipalities in province of Varese + 22 municipalities in province of Como

Table 4.1.2 List of disposing facilities and related reference area.
Source: Lombardy Regional Waste Management Plan, 2013

Among the socio-economic regressors, besides of standard indexes of education (*school*), economic well-being (*wage*), household size (*inhab_fam*), age (*age*), we computed the average real estate value per squared metre according to the National real estate register of Italian Territory Agency (a branch of Italian revenue and tax agency). We considered for all the municipalities the same category of values, namely the residential units of intermediate quality, labelled as "normal". The rationale is to verify if municipalities where the opportunity cost of establishing a diversion facility is higher because of higher real estate values, prefer to turn to MW selection.

Finally the elicited political variables are five. Three of them are different aggregations of an investigation on the political majority governing the municipality in 2012, the year of data collection; we considered a variable (*gov_6*) where the parties are catalogued in six classes: 1 = Lega Nord; 2 = PdL-Lega Nord alliance; 3 = Right-oriented Civic list; 4 = Apolitical Civic List; 5 = Left oriented Civic list; 6 = PD and allies. The same classification is given back in just three classes (*gov_3*), merging on one side the previous categories 1, 2, and 3, and on the other the previous categories 5 and 6, and obtaining in this way: 1-3: 1 = Right; 2 = Apolitical Civic List; 3 = Left. Finally (*gov_2*), we focus on the kind of the political support to the local government, differentiating between civic lists of any kind (= 0), and political alliances of any kind (= 1).

Another regressor (*cont*) deals with the political continuity (=0) or discontinuity (= 1) of the executive body governing the municipality in 2012 with the previous one. Notice that for about 5% of observations it has been impossible to recover this kind of data[37]. The rationale for the last type of analysis is to understand if political orientation has an effect on the degree of MW selection operated in a municipality.

Finally, following Mazzanti *et al.* (2012) we consider as a political item the regressor *tia*, expressing the enforcement (= 1) of a specific MW tariff (the environmental hygiene tariff, *Tariffa d'Igiene Ambientale*), more related to the amount of MW produced by each household, in place of the general tax on waste management services (= 0)[38].

The data set is too wide to be inserted or annexed in this work and it is available on request.

4.2 Estimation of the Theoretical Model

We use the first set of variables to estimate some representations of the model illustrated in Chapter 3.

The first equation we are interested to analyse is [3.1.2], describing the mechanism to produced differentiated MW:

$$d = (ek)^{\frac{1}{2}} \qquad [3.1.2]$$

To have a higher simplicity in the calculations, we imposed the condition of constant return of scale. In the following evaluation we remove this condition, estimating the equation in the version:

$$d = e^{\alpha} \times k^{\beta}$$

Because of the functional form of the equation, we run a log-log estimation with *d*, *e*, and *k* given by the observations described in Table 4.1.1:

$$\log\_d = \_cons + \alpha \log\_e + \beta \log\_k \qquad [4.2.1]$$

The outcome of the regression is the following:

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[37] Starting from official data on local elections published by Italian Ministry of Interior, we developed the analysis on the political orientation of the winner of the elections and on the continuity/discontinuity of the ruling political movement analyzing websites, programmes of candidates, and local press.

[38] The TIA tariff is composed of two parts: a fixed part, which covers the fixed costs of waste management (such as costs of cleaning streets), and a variable part, which covers the variable costs of the service, such as costs of waste collection and disposal, based on four kinds of coefficients. The general waste tax (TARSU) is simply related to the size of household living space, not following any cost-recovery principle (Mazzanti *et alia*, 2012).

Source	SS	df	MS
Model	103.0567	2	51.5284
Residual	132.6679	1519	0.08734
Total	235.7247	1521	0.15498

Number of obs	1,522
F(2.1519)	589.98
Prob>F	0
R-squared	0.4372
AdjR-squared	0.4365
RootMSE	0.2955

log_d	**Coef.**	**Std.Err.**	**t**	**P>t**	**[95%Conf Interval]**	
log_e	0.7881	0.1295	6.09	0.00	0.5341	1.0421
log_k	0.7981	0.027	29.55	0.00	0.7451	0.8511
_cons	-2.5846	0.0856	-30.19	0.00	-2.7525	-2.4167

Table 4.2.1 Outcome of regression [4.2.1]

In a framework where fitting of the model is satisfactory and the regressors significant, we obtain very close results for the parameters ($\alpha = 0.788$, $\beta = 0.798$, confirming the assumption that the effort made by households and the capital provided by the Collector play substantially the same fundamental role in producing MW selection.

On the other hand, we see that both parameters are a 57% higher than the assumed value of 0.5, and, what is more relevant, that the production function of selected MW shows increasing return of scale.

According to the previous equation the quota of MW selection depends on the exogenous variables k and e. The exercise developed in Chapter 3 allowed to endogenize the model, obtaining through backward induction a relation between q (complementary to d) and the market variables p and $\tilde{p}$; as illustrated, the functional form of q can take alternatively the functional forms illustrated in [3.2.6], [3.3.4], and [3.3.9], with the first value multiplying the sum into brackets that changes according to the degree of competition in the market. We can write it down in a general form independent from the market regime as follows:

$$q = \alpha\left[1 - \frac{p^2}{8}(\tilde{p} - p)\right] \qquad [4.2.2]$$

A problem we have with independent variables is that the observed item do not permit to separate p from $\tilde{p}$, so that we use p_{tot} as a proxy of an integrated version of both prices.

As a consequence, the final functional form we consider to study the empirical compliance of the theoretical model is:

$$q = \alpha\left[1 - \frac{1}{8}{p_{tot}}^{\beta}\right] \qquad [4.2.3]$$

where α and β are the parameters to be estimated. The rationale is on one side to verify the degree of openness of the disposal market, intercepted by α, on the other to understand the functional relation between unselected MW and cost of disposing, given by β. The last question is particularly relevant, since the function described in [4.2.2] descends even from the assumption of constant return of scale of [3.1.2]. The fact that this assumption has been contradicted by the evidence of [4.2.1], showing increasing return of scale, suggests that the quadratic form could not fit the real relation between the two variables.

To estimate [4.2.3], we run a non linear least square regression (Bates and Wats, 1988), with selected initial points respectively at 0.5 and 1 for α, and at 2 for β to interpolate the values of the data set[39].

The results of the estimation are interesting, but substantially disappointing:

Source	SS	Df	MS
Model	340.4361	2	170.2181
Residual	42.1613	1520	0.0277
Total	382.5974	1522	0.2514

Number of obs	1522
R-squared	0.8898
AdjR-squared	0.8897
RootMSE	0.1665
Res. Dev.	-1139.066

q	**Coef.**	**Std.Err.**	**t**	**P>t**	**[95%Conf Interval]**	
/alfa	0.548	0.0263	20.86	0.000	0.4964	0.5995
/beta	- 0.0619	0.2022	- 0.31	0.759	-0.4585	0.3346

Table 4.3.1 Outcome of regression [4.2.3]

As we can see, the model fits the data and the parameter α takes a value compatible with the research hypothesis of inclusion in the interval [0.5; 1]. More specifically, the final outcome gives back the picture of a Lombardy disposal market substantially closed to competition (0.55), where each disposal facility enjoys a condition of *de facto* monopoly.

But the values assumed by parameter β are non significant (besides of counterintuitive), since they suggest a positive relation between cost of MW management and the demand for it.

The reasons of this non-compliance could be of different kinds: first of all, the item used as independent variable is not the price of the end-of-the-pipe disposing service, but the general cost borne by the Local Council to let the MW be removed. Secondarily, the recalled increasing return of scale of [3.1.2], that influences the functional form of [4.2.2]. Finally, we have to consider the hypothesis that in the studied situation, namely the MW industry in Lombardy, other drivers different from the market values are more relevant to explain the real trends of selected and unselected MW, a set of items that range from physical to socio-economic to political variables.

4.3 Drivers for Waste Selection

4.3.1 The Empirical Model and the Check of Robustness

We regress the dependent variable *d* on the set of items described in the paragraph 4.1. To do so, we need to treat together different variables expressed in terms of absolute values, percentages and indexes. The simplest model to develop this line of research is to use a linear semi-log model, where absolute values are raised to the power of the parameter and regressed in logarithmic form, while percentage values are multiplied by the parameter and regressed linearly. As a consequence, the functional form to be tested is:

$$d = dens^{\alpha} \times height^{\beta} \times dist^{\gamma} \times \delta school \times wage^{\phi} \times inhab\_fam^{\eta} \times age^{\lambda} \times house^{\mu} \qquad [4.2.4]$$

with a regression function that becomes:

$$d = kost + \alpha \lg dens + \beta \lg height + \gamma \lg dist + \delta school + \phi \lg wage + \eta \lg inhab\_fam + \lambda \lg age + \mu \lg house \qquad [4.2.5]$$

We consider the correlation of independent variables:

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[39] As a matter of facts, the basis of the method is to approximate the model by a linear one, and to refine the parameters by successive iterations.

	dens	*height*	*dist*	*school*	*wage*	*inhab_fam*	*age*	*house*
dens	1.000							
height	- 0.0372	1.000						
dist	- 0.1849	0.3129	1.000					
school	0.1247	- 0.2714	- 0.1766	1.000				
wage	0.1385	- 0.2715	- 0.3281	0.7505	1.000			
inhab_fam	0.0508	- 0.3872	- 0.2457	- 0.0805	- 0.0555	1.000		
age	- 0.1247	0.2674	0.3432	- 0.0772	- 0.0768	- 0.6778	1.000	
house	0.1670	0.0965	- 0.1089	0.4294	0.4039	- 0.1362	-0.1011	1.000

Table 4.3.2 Correlation matrix for independent variables in [4.2.5]

Not surprisingly there is a strong positive correlation between *school* (an indicator of education) and *wage* (the per-capita income), and a negative correlation between *inhab_fam* (the average number of members per household) and *age* (a proxy of the elderly ratio), maybe reflecting the disappearing in Lombardy of patriarchal families and the fact that young people come out from the original family to establish a new household. Another remarkable association is between *house* (reflecting the cost of residential real estate) and the couple of variables *school* and *wage*; it is a correlation that surely descends from the common linking to the wealth of inhabitants, but that, being under 50%, suggests other relevant determinants for the variable *house*.

A linear regression model is based on four assumptions: linear mean function, constant variance of conditional distributions (homoschedasticity), independence of observations and normal distribution. We have tested [4.2.5] for misspecification and robustness using Stata command for checking homoschedasticity (testing the null hypothesis that the error variances are all equal versus the alternative that the error variances are a multiplicative function of one or more variables, through the Breusch-Pagan/Cook-Weisberg test) and normality of residuals (using Kolmogorov-Smirnov test and Shapiro-Wilk test).

Equation is not intrinsically nonlinear, i.e. independent variables have been log-transformed to effect a linearization of the relationship. We still have problems with ordinary least-squares (OLS) regression because of the non-normality of the residuals and the presence of heteroschedasticity. To solve those problems, we addressed to the fractional logit model (Papke and Wooldridge, 1996), a quasi-likelihood estimation method for regression models with a fractional dependent variable: it is a generalized linear model (GLM) with a binomial distribution and a logit link function which models the dependent variable (in our case, *d*) as a function of covariates, estimated with a robust variance-covariance matrix of the estimators (VCE).

After estimating fractional logit model we analyzed the average marginal effects, that provide a good approximation to the amount of change in *d* correlated with a one-unit change in covariates, finding almost the same values of OLS regressors.

Finally, equation [4.2.5] is enhanced with the introduction of the political variables (see Paragraph 4.1), activated as dummy regressors, i.e. independent variables which take the value of either 1 (for one category of the factor) or 0 (for the other category). In our case, the political dummies are as follows.

gov_6_1: takes the value of 1 if the ruling party is Lega Nord, zero otherwise;

gov_6_2: takes the value of 1 if the ruling party is Il Popolo della Libertà-Lega Nord coalition, zero otherwise;

gov_6_3: takes the value of 1 if the ruling party is a centre-right oriented civic coalition, zero otherwise;

gov_6_4: takes the value of 1 if the ruling party is an apolitical civic coalition, zero otherwise;

gov_6_5: takes the value of 1 if the ruling party is a centre-left civic coalition, zero otherwise;

gov_6_6: takes the value of 1 if the ruling party is a centre-left political coalition, zero otherwise.

We run the regression dropping from estimation variable *gov 6_4*, i.e. relating all other dummies to it.

gov_3_1: takes the value of 1 if the ruling party is a centre-right oriented coalition, zero otherwise (aggregating previous gov_6_1, gov_6_2, and gov_6_3);

gov_3_3: takes the value of 1 if the ruling party is a centre-left oriented coalition, zero otherwise (aggregating previous gov_6_5 and gov_6_6)[40];

Again, we run the regression dropping from estimation variable *gov 6_4*, i.e. relating all other dummies to it.

gov_2_2: takes the value of 1 if the ruling party is a civic coalition of any political orientation, zero otherwise (i.e. as the expression of a political parties coalition)

tia: takes the value of 1 if the municipality enforces a calculated tariff instead of levying a general tax to cover MW costs, zero otherwise

cont: takes the value of 1 if the municipality government has the same political orientation of predecessor, zero otherwise

4.3.2 The Results of the Empirical Analysis

The total results of the models are shown in Tab. 4.7 (OLS regression) and Tab. 4.8 (average marginal effect with Fractional Logit model for covariates in the two most complete model specifications), while Tab. 4.9 checks for the robustness of regressors.

Physical/geographical (*dens*, *height*, *dist*) and socio-economic variables (*school*, *wage*, *hinab_fam*, *age*, *house*) are all significant at 1% both with OLS and fractional logit estimation.

Considering the first group, it is remarkable the negative sign of the regressor *dist*, claiming that a higher distance from the assigned facility reduces the percentage of selection implemented by the municipality. This outcome is counter-intuitive with respect to expectations and research hypothesis, since transportation is one of the most costly activities in MW management, with a direct influence on unit costs (Massarutto, 2007). Being far from the facility would have to suggest to reduce the quantity of MW to be addressed to disposal, saving in this way the transportation costs, and to increase automatically the quota of selection. One possible explication of this result is that some other variable stronger than distance drives the recourse to landfill and incinerators: In our opinion, this driver can be the existence of property relations and vertical integration between Collectors and Disposers. We develop this intuition in next Par. 4.3.3.

Turning to the other two variables of the block, *dens* is positively correlated with the percentage of selection (the higher the demographic density of the municipality, the higher the implemented MW selection). This outcome fulfils literature (Barrett and Lawlor, 1997; Mazzanti *et al.*, 2011) and expectations, since it is quite usual to have more successful MW selection schemes in urban downtowns and where population concentrates, while in low-populated areas landfills still represent a preferable option for residual waste (Massarutto, 2015).

On the contrary, *height* is negatively correlated with *d*, suggesting that altimetry is a deterrent to MW selection, and the explication is quite similar to the previous one: higher locations of the households mean a more complex organization of collection turns and higher transportation costs for collected materials with respect to single turns requested to remove unsorted MW.

The second subset of variables deals with socio-economic characters (*school*, *wage*, *hinab_fam*, *age*, *house*), and – with the exception of the education index *school* - they all emerge as relevant. Regressors are all significant, but with different signs; *school* and *wage* are positively correlated with *d*, suggesting that both the education and the income of population boost MW selection. But, notwithstanding the high correlation between the two independent variables, we register a remarkable difference in the calculated marginal effects: almost unappreciable for *school* and more relevant for wage (see Tab. 4.8). The same positive correlation is shown with respect to *inhab_fam*, even though this final outcome could be affected by the fact that both MW selection and large fami-

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[40] The no. 3 political taxonomy would have been completed by the *gov_3_2* class, expressing the case when ruling party is an apolitical civic coalition. But it is easy to see that this group is the same of *gov_6_4*, so that we do not need a brand new variable to represent it.

lies are more frequent in small-medium urban centres, rather than in more populated towns. In this sense, a causal interpretation of the results would be more misleading than for other regressors.

Two members of this subset of items are negatively correlated with the dependent variable. The first one is the elderly average (*age*), reflecting the easy predictable evidence that, because of its complexity and the requested state of attention for it, MW selection is *no country for old men*.

The second one is the value of residential real estate (*home*) and this outcome is counter-intuitive for at least two reasons: on one hand, because of its partial correlation with the variable *wage* (see Tab. 4.5), both metres of richness of a community; on the other, because where land is more "precious" it would be efficient to allocate it to more profitable activities than the hosting of disposal facilities.

One possible explanation of this unexpected result is related with tourism. It is an activity that on one side contributes to boost real property prices through the demand for second homes and vacant dwellings (Ruggieri, 2008) and that asks for higher amenity values conflicting with the establishment of landfills (Mazzanti *et al.*, 2011 and 2012); on the other, because of temporary stay at the destination, no participation in local social capital and difficulties in understanding the local MW collection organization, tourist places are traditionally less devoted to MW selection (Mc Kercher, 1993; Coggins, 1994; Lebersorger and Beigl, 2011; Mateu-Sbert *et al.*, 2013).

To verify this intuition, we use a new estimation variable (*tourism_ratio*) given by the number of tourist nights spent in 816 out of 1,522 municipality of Lombardy over the number of inhabitants[41], and we correlate it with the variable *home*. The result is the following:

	house	*tourism_ratio*
house	1.000	
tourism_ratio	0.341	1.000

Table 4.3.3 Correlation between real estate values and tourism ratio

The correlation value is over 34% and positive. In addiction, four out of the top 10 municipalities for real estate value (Madesimo, Livigno, Bormio, and Sirmione) are in the top 10 even for tourism ratio (eight in the top 20). For this reason, we suggest that the regressor *house* is affected by the tourism dynamics and its influence on MW selection percentage is negative.

Finally, we consider the block of political variable, all expressed as dummies. The repartition of the political panorama in six positions gives just two significant regressors: the one associated to *gov_6_2* (municipal government of a centre-right coalition) and the one associated to *gov_6_5* (left-oriented civic coalition), both positively correlated to the independent variable.

This trend is confirmed by the three-class repartition (right-wing, apolitical civic coalition, left-wing), with both dummies *gov_3_1* and *gov_3_3* significant and with the same signs of the previous case. Finally, when the political orientation of the ruling group is mixed up, discriminating between civic (*gov_2_2*) and political coalition the regressor is not significant. From this analysis we can infer the implication that MW selection is a political issue, and – as we will see in last Section - that the left-wing orientation influences the decision of increasing it.

The political nature of the decision to select MW seems to be confirmed even by the continuity of government regressor (*cont*), that is negatively correlated with the dependent variable, even though non-significant[42]: increasing the percentage of MW selection is a measure that marks the difference from the previous municipal government, signalling a new political course with respect to

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[41] Original data are extracted from Lombardy Region-Éupolis data base, and referred to 2013. Due to defence of privacy, the data base permits to extract values only for municipality with at least four accommodation structures. For this reason, we have data from 436 municipalities with more than 3 accommodation sites and from 430 municipalities with no accommodation and, as a consequence, no presence of tourists over the year.

[42] Notice that non-significance of the variable disappears when we run a quantile regression (Koenker and Bassett, 1978), a procedure that solves heteroschedasticity and nonlinearity, and bootstraps to obtain robust regression coefficients, standard errors and confidence intervals of the OLS model.

the predecessors; but when this political difference do not exist (i.e. when there is political continuity), the attention for MW selection is negative, whatever the political orientation of the ruling coalition.

The last variable considered in this group is *tia*, associated with the implementation of a waste tariff connected with the actual amount of waste produced by the household, in substitution of a generic tax to finance waste management. In the strategy of municipalities, the implementation of the tariff is an incentive to increase separate collection (Mazzanti *et al.*, 2012) and our estimation confirms this behaviour: as a matter of fact, we find the regressor *tia* both significant and positively associated to MW selection, with a marginal effect, calculated as the amount of change in the dependent variable generated by a one-unit change in covariates, of almost five percentage points (see Tab. 4.9).

	OLS			**Fractional Logit**		
Variables	**Model 1**	**Model 2**	**Model 3**	**Model 1**	**Model 2**	**Model 3**
log_dens	0.0194***	0.0192***	0.0196***	0.0813***	0.0801***	0.0820***
	(0.00319)	(0.00306)	(0.00309)	(0.0124)	(0.0117)	(0.0121)
log_height	-0.0235***	-0.0237***	-0.0269***	-0.0982***	-0.0987***	-0.112***
	(0.00462)	(0.00457)	(0.00445)	(0.0197)	(0.0194)	(0.0193)
log_dist	-0.0161***	-0.0158***	-0.0164***	-0.0644***	-0.0631***	-0.0654***
	(0.00584)	(0.00584)	(0.00573)	(0.0237)	(0.0237)	(0.0232)
school	0.00296***	0.00303***	0.00287***	0.0130***	0.0132***	0.0126***
	(0.000747)	(0.000744)	(0.000723)	(0.00370)	(0.00368)	(0.00354)
log_wage	0.0853***	0.0868***	0.0965***	0.354**	0.361***	0.399***
	(0.0259)	(0.0258)	(0.0245)	(0.137)	(0.137)	(0.128)
log_hinab_fam	0.464***	0.467***	0.473***	2.000***	2.013***	2.035***
	(0.0583)	(0.0581)	(0.0570)	(0.291)	(0.289)	(0.278)
log_age	-0.168**	-0.168**	-0.209***	-0.725**	-0.728**	-0.894***
	(0.0736)	(0.0734)	(0.0728)	(0.347)	(0.346)	(0.340)
log_house	-0.0826***	-0.0811***	-0.0661***	-0.342***	-0.336***	-0.276***
	(0.0146)	(0.0144)	(0.0139)	(0.0561)	(0.0556)	(0.0531)
gov_6_1	0.0139			0.0516		
	(0.0161)			(0.0593)		
gov_6_2	0.0373***			0.147***		
	(0.0127)			(0.0530)		
gov_6_3	0.0207*			0.0812		
	(0.0114)			(0.0502)		
gov_6_5	0.0475***			0.191***		
	(0.00943)			(0.0383)		
gov_6_6	0.0323			0.126*		
	(0.0279)			(0.0740)		
gov_3_1		0.0252***			0.0991**	
		(0.00919)			(0.0392)	
gov_3_3		0.0459***			0.185***	
		(0.00932)			(0.0376)	
gov_2_2			-0.00619			-0.0227
			(0.00930)			(0.0368)
tia	0.0438***	0.0443***	0.0504***	0.182***	0.184***	0.209***
	(0.00979)	(0.00977)	(0.00967)	(0.0391)	(0.0390)	(0.0384)
cont	-0.0115	-0.0125		-0.0479	-0.0518	
	(0.00787)	(0.00778)		(0.0328)	(0.0323)	
Constant	0.497	0.471	0.461	0.00477	-0.101	-0.137
	(0.400)	(0.399)	(0.391)	(1.992)	(1.986)	(1.921)
No, of obs	1,436	1,436	1,509	1,436	1,436	1,509
R-squared	0.398	0.397	0.386			

Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Table 4.3.4 Outcome of the OLS and of the Fractional Logit regressions on [4.2.5] with added dummies

Variable	Marginal effect	Std.Err.	Z	P>|z|	[95%Conf Interval]	
log_dens	0.0202	0.0031	6.54	0.000	0.0141	0.0263
log_height	- 0.0245	0.0049	- 4.99	0.000	- 0.0341	- 0.0149
log_dist	- 0.0160	0.0059	- 2.71	0.007	- 0.0276	- 0.0044
school	0.0032	0.0009	3.51	0.000	0.0014	0.0050
log_wage	0.0881	0.0342	2.57	0.010	0.0210	0.1551
log_hinab_fam	0.4982	0.0726	6.87	0.000	0.3560	0.6405
log_age	- 0.1807	0.0865	- 2.09	0.037	- 0.3502	- 0.0112
log_house	- 0.0852	0.0140	- 6.09	0.000	- 0.1125	- 0.0578
gov_6_2 (*)	0.0365	0.0131	2.79	0.005	0.0109	0.0621
gov_6_5 (*)	0.0474	0.0945	5.02	0.000	0.0289	0.6592
tia (*)	0.0451	0.0096	4.69	0.000	0.0263	0.0640

Variable	Marginal effect	Std.Err.	Z	P>|z|	[95%Conf Interval]	
log_dens	0.0200	0.0029	6.82	0.000	0.0142	0.0257
log_height	- 0.0246	0.0048	- 5.08	0.000	- 0.0341	- 0.0151
log_dist	- 0.0157	0.0059	- 2.66	0.008	- 0.0273	- 0.0042
school	0.0033	0.0009	3.60	0.000	0.0015	0.0051
log_wage	0.0898	0.0342	2.62	0.009	0.0227	0.1570
log_hinab_fam	0.5016	0.0722	6.95	0.000	0.3601	0.6431
log_age	- 0.1815	0.0861	- 2.11	0.035	- 0.3502	- 0.0127
log_house	- 0.0837	0.0139	- 6.04	0.000	- 0.1108	- 0.0565
gov_3_1 (*)	0.0247	0.0097	2.53	0.011	0.0056	0.0437
gov_3_3 (*)	0.0458	0.0093	4.93	0.000	0.0276	0.0641
tia (*)	0.0457	0.0096	4.76	0.000	0.0269	0.0645

(*) = Marginal effect for discrete change of dummy variable from 0 to 1

Table 4.3.5 Marginal effect of significant independent variables on d according to model 1 (a) and 2 (b)

Variable	Regressors with OLS	Marginal effect on *d* with Fraclog	Elasticity with OLS (absolute value)
log_dens	0.0194	0.0202	1.9%
log_height	-0.0235	- 0.0245	2.4%
log_dist	-0.0161	- 0.0160	1.6%
school	0.00296	0.0032	0.3%
log_wage	0.0853	0.0881	8.5%
log_hinab_fam	0.464	0.4982	46.4%
log_age	-0.168	- 0.1807	16.8%
log_house	-0.0826	- 0.0852	8.3%
gov_6_2	0.0373	0.0365	Non-computable
gov_6_5	0.0475	0.0474	Non-computable
gov_3_1	0.0252	0.0247	Non-computable
gov_3_3	0.0459	0.0458	Non-computable
tia	0.0438	0.0457	Non-computable

Table 4.3.6 Regression values and marginal effects of significant independent variables on d according to model 1 and 2 and absolute value of elasticity for independent variables

According to this analysis MW selection reacts particularly to the political and socio-economic variables, and less to structural (physical) ones: being ruled by a left-wing major means almost five percentage points in MW selection more than being ruled by an apolitical civic coalition, twice the increase registered with right-wing coalition. Almost the same result is observed when the municipality enforces a tariff on MW production instead of a general tax. Other very sensitive variables seem to be the average number of members of households and the mean age, whose elasticity are higher respectively than 46% and 16%, followed by “wealth” indicators, per capita income and real estate values, having substantially the same incidence (around 8.5% in terms of elasticity), even though opposite signs. Very interesting the irrelevance of the education in the issue: albeit its significance, the elasticity with respect to MW selection is lower than 1%; this is a quite surprising outcome when compared both with standard literature on the subject (Kinnaman and Fullerton, 1999; Berglund, 2006) and with the result observed in the estimation of [4.2.1], where MW selection is strongly associated with social capital.

Even though significant, structural variables seem to be low correlated with selected MW, being the elasticity of the three regressors attested around 2%.

4.3.3 The Relation among Collectors and Disposers: a Social Network Analysis

In previous pages we remarked the puzzling evidence of variable *dist*, according to which unselected MW increases for local councils more distant to the assigned facility. We postulate that this counter-intuitive result descends from the MW industry organization, with the majority of Collectors integrated or related because of common properties with Disposers.

The rationale is that the common property of both a facility and a collecting company pushes forward end-of-the-pipe disposing, as demonstrated in Par. 3.3.4 with respect to vertical integration. To verify if this assumption is correct, we run a short Social Network Analysis (SNA) that enlighten the property linkages existing among the 13 facilities enlisted in Tab. 4.2 and the set of 24 Collectors serving at least 1% of total population in Lombardy. The following table show the companies considered in the SNA and acts as a key legend for Figure 4.3.1.

Code	Company	Service Provided in Lombardy	Collection Population Served (%)
1	AMSA Milano	Collection+Incineration	14.5%
2	Econord	Collection+Pre-treatment+Landfilling	10.9%
3	Aprica/A2A	Collection+Incineration	7.1%
4	Sangalli Giancarlo	Collection	4.6%
5	Aimeri Ambiente	Collection	4.6%
6	Mantova Ambiente	Collection+Pre-treatment	3.1%
7	San Germano	Collection	3.0%
8	Gelsia Ambiente	Collection	2.5%
9	COGEME Gestioni	Collection	2.3%
10	Ditta Colombo Biagio	Collection	1.9%
11	Area Sud Milano	Collection	1.8%
12	SCS Gestioni	Collection	1.8%
13	ASM Pavia	Collection	1.5%
14	SECAM	Collection	1.4%
15	AEMME Linea Ambiente	Collection	1.4%
16	Bergamelli	Collection	1.3%
17	SABB	Collection	1.3%
18	AGESP	Collection	1.2%
19	Masciadri Luigi & C.	Collection	1.0%
20	ASPEM	Collection	1.0%
21	Garda Uno SpA	Collection	1.0%
22	ASPEM Gestioni	Collection	1.0%
23	Casalasca Servizi	Collection	1.0%
24	REA Dalmine Spa	Incineration	
25	AEM	Incineration	
26	Silea SpA	Incineration	
27	Belissolina Srl	Pre-treatment	
28	Prima Srl	Incineration	
29	Lomellina Energia	Incineration	
30	ACCAM SpA	Incineration	

Table 4.3.7 List of MW Management Companies Considered in the SNA (Year 2012) and Key for Figure 4.3.1. Source: Lombardy Regional Waste Management Plan, 2013

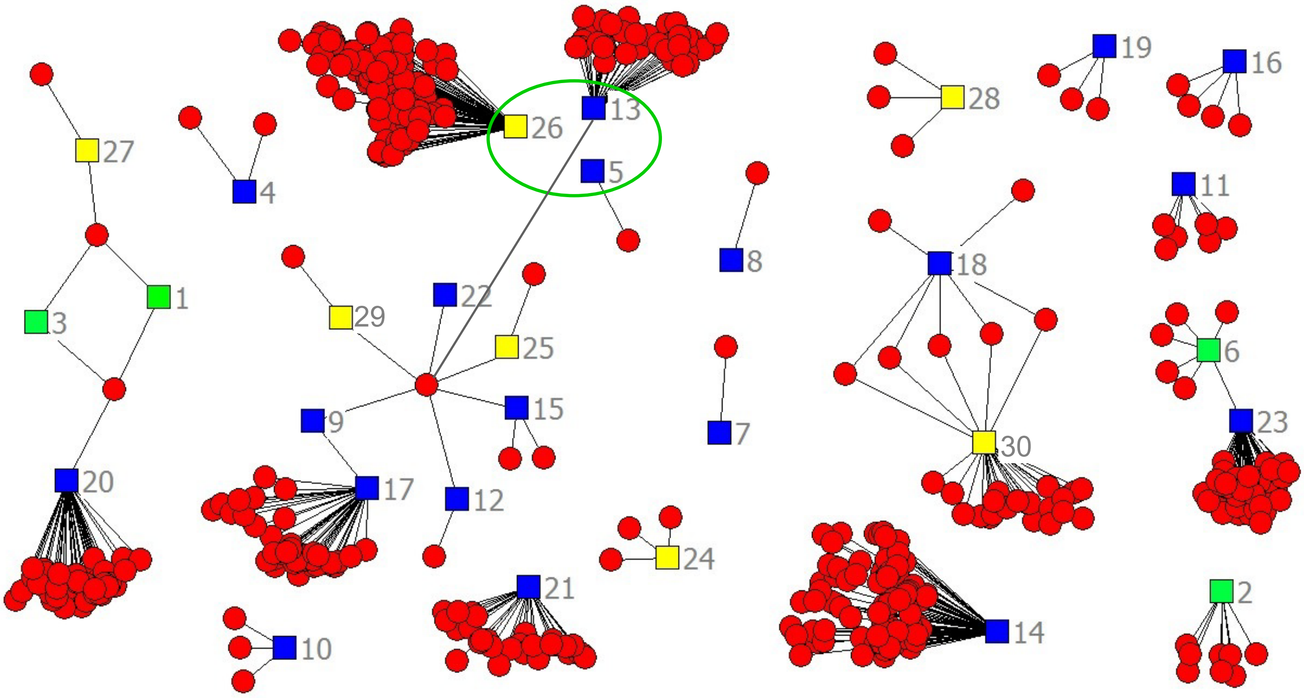

Figure 4.3.1 The SNA of the MW Industry in Lombardy

In Figure 4.3.1 the red spots identify the shareholders of each company; the green squares are companies operating in both upstream and downstream segments of the market, the blue squares are just collecting companies and the yellow ones are companies operating exclusively in the disposal segment.

In four cases, the same company provides both collection and disposing. In addiction, we can see four more clusters linking together respectively four (no. 1, 3, 20, and 27), eight (no. 9, 12, 13, 15, 17, 22, 25, 29), two (no. 18, 30), and two (no. 6, 23) companies. Finally, the green circle links together two Collectors (no. 13 and 5) with a company (no. 26) that, besides of running an incinerator, has been established as MW regulator in the province where they operate.

Even ignoring this last link, since not-based on property relations, they are 17 companies out of 30 with some kind of reciprocal integration and, what is more relevant, they gather 46,6% of the population served in Lombardy.

For this percentage of inhabitants there is a stronger commitment for the suppliers of the collection service to dispose MW instead of selecting it[43].

4.4 Final Remarks

In this chapter we have gone inside the correlation between the quota of selected (and the complementary quota of unselected) MW and a set of variables of different kinds, using a data set with cross-section observations on 1,522 municipalities in Lombardy.

The starting point has been the estimation of the theoretical model developed in Chapter 3, focusing on two general versions of equation [3.1.2] and equations [3.2.2]-[3.2.4]. While the estimation of the first one, based on exogenous variables, complies with the hypothesis, the second one does not, and the correlation between the market variable represented by the unit total cost of MW management and unselected percentage of MW is non significant.

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[43] In our analysis we apply to Collectors that serve at last 1% of the total population. This means considering just the first 24 companies, serving the 72.7% of the whole population of Lombardy. In this sense, the 46.6% computed takes even much more emphasis.

For this reason, according with literature we have looked for independent variables of other kinds, finding new correlations that confirm the role of non-market motivations in household recycling.

As a matter of fact, structural, socio-economic, and political variables show significant correlations with selected MW, even though with at least two counterintuitive evidence: the real estate value for residential, and the distance from the assigned disposal facility, both negatively correlated with the dependent variable. We explain the first negative association with the influence of tourism places, that push contextually real estate values and unselected MW; the second one with the incidence of interlinked MW management companies, providing the service of both collection and disposing, and with a consequent interest in discouraging MW selection in favour of end-of-the-pipe solutions. Notice that this can be even an explication of the non-significance of the regressor of variable p_{tot} in equation [4.2.3], a reflection that deserves further explorations in future works.

The most interesting evidences are from the study of the behaviour of political variables. Apart from the implementation of a specific tariff or a general tax, an issue that deals with environmental policies rather than political addressing, this kind of items are rarely used in the waste field, and with no conclusive evidence. Many contributions in the track of the so-called "convergence" school - according to which modern societies challenged by the same kind of problems use the same set of solutions, so that ideological differences have narrowed in last decades - claims that political differences do not matter to explain variations in policy outputs (Skinner, 1976; Thomas, 1980). Nonetheless, Feiock and West (1993), find out confirmations on the influence of party competition and interest groups activity on the percentage of household recycling, while Benito-López *et al.* (2011), argue that municipalities governed by progressive parties are more efficient in implementing MW management.

Our results assert that it does exist a positive and significant correlation between MW selection and the ruling of the municipality by a political-oriented coalition, and that when the government is left-winged the percentage of selection is higher than in the other cases. This interpretation would be confirmed by the evidence that interest in MW selection fades away when the ruling coalition has been confirmed in last elections, but this final observation is not supported by the results for the regressor *cont*, that are significant when we run a quantile regression of [4.2.5], but not with other estimation procedures (OLS or Fractional Logit).

Another political variable that shows a tangible correlation with *d* is *tia*, an outcome that confirms the interconnection between recycling and the enforcement of unit pricing schemes enlightened by both national surveys[44] and literature (Nestor and Podolsky, 1998; Kinnaman and Fullerton, 1999; Bilitewski, 2008; Le Bozec, 2008; Mazzanti *et al.*, 2012)

Among socio-economic variables, the real surprise is given by the education index, whose connection with the percentage of selection looks negligible, while very relevant appear all the other regressors, from households size to per capita income, and real estate values. On the contrary, the elasticity of MW selection with respect to geographical variables is quite low.

Finally, for some regressors the verse of causality between dependent and independent variables is ambiguous a priori, and confounding factors could influence the connection: this could be the case for distance from facility, probably affected by the kind of relationship existing between Collector and Disposer, and for real estate values, possibly pressured by tourism dynamics.

For this reason, we have to recall once again and finally that the whole analysis presented in this pages dealt with correlation between variables and not with causality.

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[44] For a complete review see European Environmental Agency National Annual Reports on MW management.

Chapter 5:
The Spread of Innovation in the Municipal Waste Industry

In Chapter 3 we considered a situation where a more efficient outsider can enter the disposing segment and even exclude the incumbent, with the propensity to exclude directly related to an efficiency parameter β (see Section 3.3.3).

This is a typical dynamic of the current European MW industry, where incinerators with energy recovery are progressively substituting old and inefficient landfills. In those cases the process is driven by incinerator technology producers that benefit from the opportunity to win over the competition and to gain a monopolist position in the disposal market.

Another dynamic analysed previously in Chapter 3 deals with the organizational innovation given by the wave of vertical and horizontal merges that involves MW industry in the last years; an innovation that, according to Section 3.3.4, ends once more with an increase in unselected MW generated.

In this Chapter, we explore the issue of innovation in MW industry to understand if the final outcome of a technological change is necessarily an increase in the percentage of unselected garbage or, put in another way, if innovation in this industry is compatible with activities that are labour- rather than capital-intensive, such as selection and recycling.

To follow this line of research, we analyse the notion of innovation when related to the MW industry (Section 5.1) and with respect to literature on the topic (Section 5.2), using both the Neoclassical (Section 5.3) and the Complexity Theory (Section 5.4) conceptual frameworks as theoretical tools to interpret the actuality of MW management.

5.1 Process, Product, and Organizational Innovations in the MW Industry

As illustrated in Chapter 2, since Schumpeter (1919) technological change can be labelled as process, product, or organizational innovation. When applied to MW industry, this classification provides the ability to clarify the nature of innovation for many practices and artifacts.

Process innovation deals with capital intensive plants in the segment of disposal, aimed at reducing wastes by incinerating, pyrolyzing or composting them to generate energy and products that can be used for other activities, even combining all these techniques to optimize waste minimization (Dunmade, 2013).

With respect to downstream technologies, there exist three main innovation fields: the most mature one, with a technology developed around thirty years ago, is the procedure to obtain Refused-Derived Fuel (RDF) from waste; more recent are the technologies to obtain thermal and electric energy from waste incineration, currently joint with the progressive reduction of ashes and particulate matters in the fume emissions. Finally, the highly advanced plasma torch incineration, a technology that does not generate toxic gas emissions, particulates or slag, however is still too costly to be exploited in the waste industry. Other innovative techniques involve biological and mechanic treatments of MW, aimed at reducing the amount of biodegradable waste to be transported to landfills.

Process innovation is mostly connected yet not exclusively with end-of-the-pipe disposal, as well as waste selection and recycling. New techniques with different technology contents are pre-paid waste bags, in some cases equipped with transponders, street dumpsters with electronic scales and skullcaps, or underground collection points.

Pre-paid waste bags system is an instrument at the intersection between process and organizational innovation, invented in Switzerland in mid-1990s. The rationale is to sell plastic bags, validated by the local body responsible for MW management, as the ones and only accepted for the conferring of non-recyclable waste, while selected MW can be conferred in free transparent bags. Because of the expenditure in waste bags, households pay inversely to the effort in selection they make, being motivated not only to sort final MW but even to reduce the purchase of goods with higher “content of waste” (non-recoverable materials and packaging).

In an attempt to be better identify the amount of unsorted MW produced and to efficiently charge households in a timely matter, new tracking systems have been introduced in the last years. They are based on the application of an electronic chip with transponders tagged to plastic bags, in order to identify and automatically memorize searchable data tagged either through radiofrequency devices positioned on the waste collection vehicles or remotely controlled. This technology, called Radio Frequency Identification (RFID), allows the storage of data on the number of purchased bags, the weight of conferred sacks, the number of conferment/emptying (when the tag is associated not to waste bags but to dump bins), and the geographical origin of unsorted MW, all useful information in order to make MW management more effective. Other ICT applications to the MW field call into question the implementation of software and the use of electronic devices to track and measure garbage, and to dematerialize and simplify the billing system.

Another technique to deter the conferment of unsorted waste, especially in settings characterized by non-domestic users such as shops and offices, is the electronic and skullcap equipped street dumpster. It is a common dump for street MW collection with a reduced insertion compartment to limit the conferring of bulky materials, and a magnetic opening key that permits the user’s identification and association with the conferred waste.

In recent years, there has been an increased diffusion of the installation of a complete series of collection dumps in city centres and downtowns (the so called “ecological islands”) positioned at underground street level, with a pneumatic or mechanical elevator system that raises the container at the moment when waste is being dispensed. The rationale of this technique is to make waste selection more efficient in constrained areas, for instance downtown areas, in order to refrain from the occupation of limited space and avoid the unpleasant visual impact of street dumpsters.

Product innovation in the field of waste means using new concepts in producing consumer goods. It is an issue that calls into question the activity of eco-design, i.e. the practice of designing objects assuming the purpose of minimizing environmental impact both during their use and post product lifecycle.

This requires dematerialization, i.e. the reduction of the amount of materials used per unit output and the minimization in packaging, a waste stream accounting for between 15% and 20% of total MW in different countries (Nicolli and Mazzanti, 2011). The reduction of packaging could be considered in a broader sense, meaning both the reduction of the wrappings associated with the product and the establishment of refills and recharges in products such as detergents, beverages, ink cartridges, and so on. Being strictly related to a new way in organizing retail segment, this novelty stands at the ideal intersection between product and organizational innovation.

Besides dematerialization, product innovation even takes the form of a configuration for disassembly that gives performing results at the moment of dismantling and disposal, when many parts and components can be recovered as raw materials, and of a conception for repeated use of the good. Finally, product innovation in the last years has also meant design that fosters energy efficiency and energy saving, especially with respect to electronic devices.

The last group of innovation that we consider is organizational. It deals with two conceptions in waste collection and service charging. The first one, anticipated in the introduction to this Chapter, reflects the approach of multi-utility throughout Europe that has launched a relevant mergers campaign and modified the industry’s organizational scenario in last 20 years. The second one consists in implementing collection schemes based on door-to-door, kerbside or proximity collection when the other two are hindered due to logistical features related to altimetry or urban sprawl, with a source separation process that begins inside the households, or even more sophisticated systems like the one-on-one pick up for Electrical Waste and Electronic Equipment (WEEE), committed to electrical and electronic device retailers and sellers. More rare and ingenious methods are the use of "eco-mobiles", i.e. multi-compartment vehicles temporarily located in places to provide the services normally covered by collection centres for materials such as exhausted oils, bulky MW, and WEEE. Another unusual system implemented in perched villages, characterized by narrow streets and space constraints, is the garbage separate collection with mules that substitute vans and minivans. It must be pointed out that many techniques can be perceived equally as either organizational or process innovations, and an exact classification in this sense is difficult.

Strictly related with different MW selection organization systems and processes, there also exist new methods for the service financing, all aimed at charging the user for the real amount of generated waste, or for a good proxy of it. They are methods often characterized as experimental, that in many cases still mix together a flat rate based upon parametric calculations (related with the number of members of the household or the habitation size) and a direct measure of the conferred waste. The most common are the so called Pay As You Throw (PAYT) tariffs, and other kind of unit pricing such as the Italian Environmental Hygiene Tariff (*Tariffa d'Igiene Ambientale*, TIA).

Another interesting innovation classified under the organizational category are product leasing schemes developed by certain providers; they are manufacturers who prefer to manage their goods throughout their products' service life directly with their customers; at the end of the lifecycle, they retrieve and/or either upgrade or remanufacture the goods.

5.2 Innovation and Municipal Waste: a Critical Review

Innovation in the MW Industry is a topic that is quite often neglected in economic literature and usually only included in the wider subject of eco-innovation.

Definitions of eco-innovation (Kemp, 1997, 2010) highlight the ecological attributes of individual new processes, products and methods from a technical and ecological perspective. The Measuring Eco-Innovation research project defines eco-innovation as the production, assimilation or exploitation of a product, production process, service or management or business method that is novel to the organization (developing or adopting it) and which results, throughout its life-cycle, in a reduction of environmental risks, pollution and other negative impacts of resources and energy use compared to relevant alternatives. The inclusion of new organizational methods, products, services and knowledge oriented innovations in this definition differentiates from the definition of environmental technologies as all technologies whose use is less environmentally harmful than relevant alternatives (Kemp, 2010).

Several papers investigate eco-innovation drivers. These include Parry (2001), which argues on the impact of environmental policies on technological innovation, Horbach *et al.* (2012), who focus on the German regulated industry to assess the drivers of eco-innovation, claiming that the existence of consumer demand for environmental quality boosts eco-innovation in the areas of recycling and use of materials; Kneller and Manderson (2012), which examines the link between eco-innovation and regulation in the United Kingdom; Rehfeld *et al.* (2007), concluding that the relevance of demand pull factors for eco-innovation is mixed. Another research line investigates the role of policy schemes and regulation on the so called Porter hypothesis (Ambec and Barla, 2006, Popp *et al.*, 2009; Costantini and Mazzanti, 2012).

Applying more specifically to innovation in the MW management realm, Managi *et al.* (2012) analyse the technology adopted by municipalities in Japan, suggesting that inappropriate incentives for technology adoption can arise. Nicolli and Mazzanti (2011) explore the existing relation between environmental policy implementation and the patent application in the area of European Union recycling and waste management technologies, obtaining that regulation does seem to play an important role in the promotion and diffusion of innovation (see Section 5.5), even though from the 1990s its effect has been less pronounced. Cainelli *et al.* (2014) develop a joint theoretical-empirical investigation, with a model including idiosyncratic institutional and economic features of the territory, to find the key elements of regions that foster waste and resource use related innovations. In line with the emphasis on external innovation as more important than classic drivers of innovation, such as R&D, they conclude that firms located in regions where commitment to waste management to increase recycling is stronger are more likely to adopt innovations aimed at reducing waste and materials, while waste related innovation seem not to be sensitive to the presence of R&D.

5.3 The Innovation in the MW Industry as a Market-driven Process: a Neoclassical Perspective

According to neoclassical theory, innovation is pushed mostly by market forces. The standard situation in which innovation spreads is when an outsider wants to enter a new market occupied by an incumbent to substitute or to flank him. The reason that makes it possible for the outsider to challenge the incumbent is innovation, i.e. proposing a new product more appreciated by consumers or the same product at a lower unit cost and at a consequent lower market price.

As anticipate in Section 2.3, neoclassical economics label as “leapfrogging”, the situation when the outsider is able to send the former incumbent off the market thanks to the introduction of an innovation, which in this case would be called “drastic”. On the opposite side, “incremental” innovations allow the outsider to enter the market just enough to cohabit with the incumbent.

In the MW Industry, drastic innovations are quite rare and mostly related to the introduction of new generation end-of-the-pipe facilities. In this sense, the main innovation of last years has been the introduction of waste-to-energy technology, with the first full-scale commercial facility, the Arnold Chantland Resource Recovery Plant in Ames (Iowa), that started the operation in 1975 (Sovacool and Drupady, 2011). The technology earns credit in the disposal market at the end of 1990s, slowly substituting the former disposal landfills in many districts..

As illustrated in Section 3.3.3, the recourse to waste-to-energy incinerators can act both as a drastic innovation, with the new technology that leapfrogs the old landfill, and as an incremental one, meaning the fact that the two technologies maintain co-existence in the disposal segment. The discriminating factor between leapfrogging and cohabitation is the unit revenue extracted from the technological change, given in the prospected case by the market value of recovered energy, so that when it is higher than a particular threshold, exclusionary price by the innovator for the service of disposing is favourable. On the opposite side, the energy revenues are not so promising to make a price cut in the provided service advantageous , and no efficiency effect comes into action.

In the current MW industry, the state of the art seems much more addressed to cohabitation of landfills and waste-to-energy plants, rather than to leapfrogging and substitution of old technologies with more innovative ones. A reason for this can be sought in the lock-in effect of the sunk costs borne by operating facility: even though it is higher for incineration plants than for landfills, the latter ones need initial investments to be written off in 10 years or more.

A further assumption that is typical of regulatory economics postulates that the absence of competition will reduce the incentives to operate efficiently, especially when facilities are allowed to charge their full cost to customers. The argument, deeply rooted in the Arrow’s intuition on incentive to innovate (Arrow, 1962a) is not frequently analyzed with MW industry, but there is some empirical evidence that confirms it (Massarutto, 2015).

Another topic that usually belongs to neoclassical innovation theory is the study of R&D dynamics and incentive to innovate. In the waste industry, the degree of investment in R&D is quite low, and technological change is mainly embodied in capital equipment, rather than in the waste management sector itself (Nicolli and Mazzanti, 2011). This is someway surprising when we consider that the evolution of the industry is in the direction of the rise of bigger and more capitalized firms, with higher investment capacity. Nonetheless, in a market heavily regulated and characterized by non-drastic innovation, the incentive to innovate is insufficient, and Denicolò (2002) shows that even incumbents' interest in R&D is very low in industries characterized by non-drastic innovations and low propensity to invest (see Section 2.3).

It is a long debated question whether innovation is a public or a private good and under-provided R&D must be considered a market failure (Griliches, 1958; Jaffe, 1986; Levin, 1988; Klette *et al.*, 2000). If so, public intervention can allow a satisfactory level of R&D and innovation; the theoretical literature on the relationship between environmental policy and technical innovations has claimed for the superiority of market-based instruments such as taxes, subsides and tradable permits (Downing and White, 1986; Milliman and Prince, 1989). In the waste management industry for a long time this has taken the form of incentives and green certificates emission on energy produced from waste incinerators.

Recent studies confirm the superiority of market-based instruments with perfect competition and full information, but they maintain that the situation changes when firms gain strategic advantages from such innovations (Carraro, 2000; Montero, 2002); in those cases standards seem to be a more appropriate policy (Rennings *et al.*, 2006).

An issue considered in Section 3.3.4 is the vertical merger between the Collector and a Disposer discussed in previous pages, along with horizontal mergers between operators of the same segment, as one of the most relevant organizational innovations affecting the waste industry in the last 20 years. Since Williamson (1968), economic theory pointed out the potential relationship existing between firm concentration and efficiency gains. Farrell and Shapiro (1990) develop a smart analysis on horizontal mergers, highlighting that the efficiency gains generated can exceed the gains from market power. The sources of potential efficiency gains from mergers are related to the capture of economies of scale and of scope (the latter quite typical with the transformation of municipalized waste firms in modern multi-utilities involved in gas, water and electricity provision as well), and cost savings generated by rationalisation of distribution, administration and marketing activities, with the relevant notation that their impact on market prices, i.e. on the consumer surplus, is related to the possibility of reducing variable rather than fixed costs (Motta, 2004).

Mergers have been identified by competition theory as a possible tool for market monopolization because of the opportunity for the integrated operator to provide the good/service at a price lower than rivals; vertical mergers because of the elimination of the double marginalization problem and horizontal mergers because of the exploitation of efficiency gains. At the global level, we see that this organizational innovation has shifted a formerly very fragmented system towards a concentration, rather than a monopolization, with bigger and more efficient operators competing in wider markets, with potential positive feedbacks on the total price of waste management and, as a consequence, on consumer's surplus.

Going back to the model of vertical integration developed in Section 3.3.4, because of the exogenous nature of the price of waste removal p, the gains from integration are not exploited by the integrated operator in terms of more competitive prices, and the organizational innovation produces an increase in profit through the growth in the percentage of unselected waste, and no efficiency effect is enjoyed by the consumer. The scene changes when we remove the invariance of price p, for instance considering a long run model where a social planner can choose the best price p through an auction. In this case, the organizational innovation has an efficiency effect, and the total welfare increase is shared between integrated operator and consumer.

The final result in this occurrence is the same of a process innovation, either drastic or incremental, that positively affects the efficiency of the disposal facility, i.e. an increase in unsorted MW.

In conclusion, assuming a neoclassical perspective on the issue of the role of innovation in the waste management industry means to focus mainly on process innovations in the end-of-the-pipe segment. As a matter of fact, neoclassical theory is more comfortable in treating drastic innovation inducing technological change, R&D investments and patent applications to win a market competition. This hardly fits with a sector such as the waste management industry, where innovations are mostly non-drastic, R&D is low and policy driven, and the market is both highly regulated and progressively more concentrated, so that the incentive to innovate could affect the once in a while competition for the market, rather than the day-by-day competition in the market.

For all these reasons, we search for other paradigms more appropriate to describe the rise of innovation and technical change in the waste management industry.

5.4 The Innovation in the MW Industry as a Social Process: a Complexity Perspective

In the last 30 years, neoclassical economics of innovation has been challenged by new theories that rescue the Marxian intuition of innovation not being the result of individual ingenuity of isolated inventors nor, in a more modern acceptation, the outcome of specialized R&D units, rather as a matter involving the whole society: a social interaction and a historical process, rather than a market one.

These theories start from the observation that the majority of innovations in history have been non-drastic, and even technological discontinuities have been the result of incremental changes, rather than of disruptive ones (Rosenberg, 1983), and focus on the notion of uncertainty as the most relevant in treating the issue of change. To reduce the degree of instability that invariably accompanies innovation, a prominent role is played by institutions, that support firms and economic operators in facing the "ontological" uncertainty related to change (see Section 2.3).

5.4.1 Heterodox approaches to innovation economics

As pointed out previously in Section 2.3, heterodox approaches to economics of technological change have two main strands in the National System of Innovation studies (Nelson, 1992; Lundvall, 1993), and in Complexity Economics (Arthur *et al.*, 1997).

National System of Innovation studies concentrate on idiosyncratic features of a country and on existing relationships internal to it affecting generation, diffusion and selection of skills and knowledge useful to the economic system.

A similar approach is applied to waste management by Cainelli *et al.* (2014), although at the regional instead of the national level. They investigate the drivers of environmental innovations in institutional and economic features of the territory, searching for the key elements of regions (policies, infrastructures, social capital, firms' organization, sector and geographic policy based factors) that foster waste and resource use related innovations. They find that, given the public good nature of MW management, market forces are not sufficient to ensure the deployment of a satisfying level of innovation in that sector, and policy content of regional frameworks, along with firm-related factors, matter more than R&D investment to explain the adoption of waste technologies (Cainelli *et al.*, 2014).

According to this framework, the national industry characteristics and its historical evolution are at the origin of the innovation trajectories of different countries. For instance, the early implementation of prevention inspired principles or extended producer responsibility schemes such as German or Danish Duale Systems are at the basis of the organizational innovations entailed by shifting from landfill to MW selection (see Section 1.4).

Complexity Economics focuses on non-equilibrium dynamics and adaption strategies by heterogeneous agents, agents' interactions, role of institutions in addressing the system to one of the multiple available equilibria, multilevel decisions.

Lane and Maxwell (1997) apply the complexity framework to the issue of innovation, maintaining that it is firstly a knowledge action: a change in the standard way in which an agent looks at artifacts, and the assignation of new functions to existing objects.

To our knowledge, there is no complexity study exploring the waste industry as of yet, however we but we affirm the notion that complexity is the most promising theoretical framework to deal with the non-drastic, organizational and non-technological innovations that characterize waste management.

5.4.2 Market Systems in MW Industry

In previous pages we have illustrated the fundamental definitions of the complexity economics innovation theory (see Section 2.3); perhaps the most relevant among them is the notion of "market system", which does not mean the simple and aseptic neoclassical concept of where demand meets supply, rather "a set of agents involved in recurring interactions, and organized around a family of artifacts. Through interactions agents require design, produce, trade, provide, install, use and preserve artifacts, generate new assignments to functions and develop new artifacts to confer them the assigned functions" (Lane and Maxfield, 1997).

A market system differs from the standard notion of market because of the emphasis on the fact that interpretation of the social environment, and not hedonistic behaviour, drives individual action and choices. It is a notion that, aside from agents considered with their different features, other factors include the interplay of institutions, social and legal norms, fads, geographical characteristics, technological *status quo*, firms organization, property system, and so on. A generic market system of MW can be outlined as follows:

Categories	Items
Agents	European/National law- and policy-makers Regional planners District organizers/controllers Municipal policy makers Collection operators Disposer operators Equipment suppliers Product designers Production chain consortia Households and assimilated (offices, retailers, shops)
Artifacts	Waste bags Transponders Waste tracking electronic equipment Domestic bins Street dumpsters Subterranean dumpsters MW depot (ecological islands) Collection means Waste-to-energy plants Incinerators Landfills RDF
Interactions in the space agents-artifact	Types of collection Street collection Kerbside Mixed (Some materials collected at home, other with street dumpsters) Light multi-material (mixed collection: paper, plastic, Tetrapak and metals) Heavy multi-material (as above + glass) Types of disposing Landfilling Incineration Incineration with energy recovery Mechanical sorting and materials recovery Types of charging Waste tax PAYT Mixed (Waste tax with discounts and variable charges)

Table 5.4.1 The Market System of European MW

In previous Chapters we depicted a chronological evolution of MW sector that called into question the notion of market systems. Albeit the framework of integrated waste management nowadays is emerging throughout Europe (see Section 1.2), different MW market systems still coexist, each of them using a proper set of artifacts, assigning new functions to them, and being characterized by particular kinds of interactions.

Based upon the classification in Table 5.4.1, we can identify at least four market systems in MW industry:

1. "traditional" system, entirely landfill oriented;
2. "waste-to-energy" system, deeply incinerator oriented;
3. "light recycling" system, with integrated solutions and selection percentages lower than 50%;
4. "hard recycling" system, addressed to selection percentages higher than 50%.

Although still relevant, the traditional system is bound to disappear within the next years. It can call for either integration or separation of collector and disposer, and it is usually based upon street collection, and the bestowing of MW to landfills. The relevant artifacts for this market system are street dumpsters, truck compactors and landfills, the interactions are monopolized by street collection and landfilling, while the substantially nil involvement of households in collection does not call for any PAYT charging system.

According to Complexity economics, a necessary condition to observe the rise of innovations in a market system is to have "generative relationships" among the agents (see Section 2.3). In the traditional market system, the nature of interactions is quite barren: relations are minimized and based on commercial or technical basis (the public tender to find the collection or the integrated operator, the organization of collection by the entrusted operator, the contract between collector and disposer), while participation by household is absent.

As a consequence, it is not surprising that innovation in this market system is depressed and dating back to 20 or 30 years ago, regarding operations to make landfills safer (new coating solutions, abating systems for dioxin), and for the automation of street collection (CCTV for a better approach of truck compactors to dumpsters as well as mechanical solutions for lifting and emptying dumpsters).

The "waste-to-energy" market system is based on end-of-the-pipe facilities, as the previous one, but represented in this case by incinerators revamped and upgraded to the version of energy recovering plants. It is a "hard industrial" market system, where the incinerator is the key artifact, often characterized by the presence of vertically integrated operators (see Section 3.3.4). The whole MW chain is oriented to feed the end-of-the-pipe incinerator to its minimum optimal size, meaning that the collector will not be induced to a sophisticated selection that would subtract raw materials to the plant, and that the system as a whole is not focused on t recycling. As a consequence, the collection phase is mainly drawn upon undifferentiated street dumpsters[45]. Being no interest in rewarding a reduction in MW, "virtuous" schemes such as PAYT are useless, and standard taxes or fees are the common tool.

As for the previous market system, the relationships among agents are infrequent, and limited to procedural exchanges that involve experts and technicians; innovation in this market system is not the result of generative liaisons between agents, but of the technology embedded in incinerators, its origin is placed in a sector external to MW industry.

The "light recycling" system is perhaps the natural outcome of the integrated approach to MW management. It involves both recycling and end-of-the-pipe disposal, so that the key artifacts range from waste bags, domestic bins and ecological points of collection to street dumpsters and incinerators. The collection phase normally runs through a mixed system of street and kerbside collection, even inside the same municipality, with different numbers of materials that are selected.

Being a very assorted market system, the interactions among actors are frequent and varied. Collectors and municipal policy makers debate stably to fit the recycling targets of EU, improving the separate collection; the MW management involves quite deeply household asking for an increasing effort in waste sorting and proposing to them evolving schemes of collection (separation of new

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[45] This description of the market system has been rejected in last times by proponents of a "mixed" vision, suggesting that the primary need of waste-to-energy plants is not the fulfilling of the minimum optimal size, but the search for efficiency, that claims for the selection of higher calorific materials and the discarding of others streams, in particular wet waste. This is the point of view proposed by the "Zero landfill" narrative (see *infra*).

materials, scheduled retreats, use of admitted plastic bags). As the higher involvement of citizens claims for more sophisticated payment schemes, PAYT tariffs progressively replace the waste tax. This asks for a change in the common artifacts, for instance in the street dumpsters, that are equipped with scales, skullcaps and electronic keys that allow to register more precisely the quantity of MW conferred and to match it to the real deliverer. Nonetheless, the existence of a wider network of agents favours the rise of innovation even in the form of assignment of new functions to existing artifacts: this is the case of RFID and transponders (see Section 5.1), commonly used in electronic ticketing systems and in logistics, and applied to waste bags. The same happened with underground dustbins, whose technology belonged to those firms operating in the construction of garages and parking and proposed as a solution to locate dustbins avoiding the ground occupation in urban environments.

Finally, the "hard recycling" system is the market system of the integrated approach once addressed to the target of a MW selection higher than 50-60%. Hard recycling is the market system that fulfills the prospected evolution of MW management according to the EU Priority Ladder Principle (see Section 1.3).

Banning the landfill and considering the incinerator a residual and temporary option, means to elect as central agents collectors and the production chain consortia; the involvement of households is the most, regarding not only the awareness on the best way to select MW, but even the education in choosing goods with lower contents of packaging. Interactions are characterized by the kerbside collection method and by PAYT charging, with artifact such as pre-paid waste bags and tracking equipments. Besides the previous, other innovations in this market system are of organizational kind: the need to reach higher performances in collection and selection drives the introduction of minute solutions, such as the eco-mobiles and the cited use of mules as collection vectors in perched urban centres (see Section 5.1).

5.4.3 Narratives and Scaffolding Structures in MW Industry

According to Complexity theory, innovation is mostly a cognitive act given by a representation of the space shared by agents and artifacts that generates a new, socially determined, market system. This one is subjected to pressure from both internal and external factors, produced by the interaction among agents and in turn generating instability on the assignment of functions to artifacts and to social conventions that regulate interactions on agents; the pressure raises until a new market system replace the old one.

With regard to the MW industry, the internal changes are provided by the above mentioned new artifacts that have emerged: the refinement of the waste-to-energy technology, the availability of low cost RFIDs and transponders and the underground or the scale equipped dustbins. The external change dealt with the EU regulation in the form of , on one hand, distinction between services of General or Economic Interest (see Section 1.1), and on the other, of the mentioned emphasis on the Priority Ladder Principle. In the case of Italy, a relevant external change has been conveyed by the direct election of Mayors that has changed the relationship between Municipality policy makers and the community, with the former compelled to seek new indicators to measure their political performance and to ask their electors to vote on them. Recycling addresses this need, and indeed the target in terms of MW selection has been turned into an issue that characterizes the political orientation of a Local Council (see Section 4.3.2).

The interaction of internal and external changes generates "ontological uncertainty" and instability on agents (see Section 2.3) that have to update their behaviours according to the new market system. Examples of instability in the Italian MW realm are given by the case of the Municipality of Melpignano (Province of Lecce, in the southern part of Italy), where the Local Council, unsatisfied with the results so far, decided to join the hard recycling market system, and decided to completely remove all street dustbins in the city in only a few days, creating a situation of wide disorientation throughout the community. Another similar example is given by the Municipality of Casalecchio di Reno (Province of Bologna, in the northern part of Italy) where, since 2013, street collection has been banned and the movement for the abandoning of rigid door-to-door collection has given rise to a political coalition for 2014 municipal election.

To deal with instability and to confine the ontological uncertainty that is a natural consequence generated by innovation, agents can draw upon the two kinds of instruments given by "Narratives" and "Scaffolding Structures", both fundamental notions in the Complexity framework, as pointed out in Section 2.3.

Since uncertainty prevents agents from seeing the consequences of their actions, thanks to the Narratives, they are able to give a rationale to what happens. In this sense, a Narrative identifies the cognitive process that allows agents to orient their future actions, to compare it with other point of views, even to change the Narrative, so to address their action to medium- and long-run objectives.

In MW management, different recognizable Narratives exist, some of which play relevant roles in justifying and supporting some of the market systems illustrated in the previous section. The most famous are the "Zero waste" Narrative and the "Zero landfill" Narrative.

Zero waste is the name of an approach in MW management that promotes the feasibility of an almost complete elimination of MW disposed in either landfill or incinerators. It is supported by an international network of non-profit associations, the Zero Waste Alliance (ZWA), which helps industry and communities to pursue "a future without waste and toxic materials".

According to ZWA, "Zero Waste is a goal that is both pragmatic and visionary, to guide people to emulate sustainable natural cycles, where all discarded materials are resources for others to use. Zero Waste means designing and managing products and processes to reduce the volume and toxicity of waste and materials, conserve and recover all resources, and not burn or bury them. Implementing Zero Waste will eliminate all discharges to land, water, or air that may be a threat to planetary, human, animal or plant health"[46].

The Zero Waste Narrative set an ambitious future objective (closing the loop of materials phasing out toxic materials and emissions) giving to the community of participants, made up of business agents and municipalities, a ten-step road map to achieve it. In this sense, the Zero Waste strategy calls for 10 actions to be implemented:

1. community involvement for the implementation of waste selection (waste management as an organizational rather than a technological issue);
2. implementation of kerbside or door-to-door collection (only collection method deputed to get a 70% recycling target);
3. creation of a compost machinery, in particular in rural areas (closing the loop and shortening the use chain);
4. creation of recover and recycling platforms (selecting materials to be re-used in the production process);
5. reduction of waste (through consumption of tap water, refillable bottles, banning of throw-away products);
6. creation of repair and re-use centres (second hand and flea markets, repair laboratories and workshops);
7. implementation of price uniting in waste tariffs (rewarding virtuous behaviours and supporting responsive purchase decisions);
8. creation of a second inspection recover and selection machinery (recovering further materials that escaped the first selection, stabilizing the residual organic waste fraction);
9. creation of a research and design centre to run studies and analysis on the residual waste from selection, the industrial design of products, the corporate social responsibility of firms);
10. final cancellation of waste, to be reached within 2020.

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[46] www.zerowasteeurope.eu/about/principles-zw-europe, consulted November 21st 2014.

The Zero Waste network conjoins several associations throughout the world. In Italy, it associates more than 200 municipalities committed to undertaking a process that, even though hardly leading to the cancelation of waste within 2020, could allow a 70-80% of MW selection and recycling.

Another prominent Narrative in the MW realm is the Zero Landfill option. Perceived as a deception by Zero Waste advocates, this Narrative promotes the integration of different waste management methods in order to achieve the objective of dismantling landfills in favour of a mixed system of recycling and waste-to-energy plants.

On a global scale, the incineration segment still exhibits significant growth trends (Eckhard, 2013), mostly in EU countries experiencing a transition dominated by the aim of phasing out landfills as much as possible. There is a clear correlation between incineration, recycling and landfilling; countries that divert less than two kilograms/year per capita adopt a balanced combination of incineration and material recycling, while countries that do not incinerate rely on landfill for more than 30% of their MW. According to proponents of this Narrative, this is a hint that incineration is complimentary, rather than contradictory, to recycling in the effort of phasing-out landfills (Massarutto, 2015). At the same time, countries that achieved a higher share of incinerated MW show a mature situation, fostered by the decoupling trends of waste generation from economic growth (Mazzanti *et al.*, 2012), generating an excess of supply during the last decade and a foreseeable further limitation to the expansion of this market.

Both technical (Cossu, 2011; Brunner and Rechberger, 2014) and economic literature (Massarutto *et al.*, 2011) look at MW incineration as a key element of an integrated MW management strategy, emphasising complementarities, rather than opposition, between recycling and energy/thermal recovery from MW.

The energy issue is stressed by the promoters of the Zero Landfill Narrative as a relevant environmental outcome of this approach, since energy from waste is 50% due to renewable materials contained in the waste flow (Manders, 2009), while estimates claim for a potential doubling of energy generated from waste by 2020 (Massarutto, 2015).

On the other hand, incinerators are challenged on the basis of environmental and health arguments, related to air pollution, GHG emissions and the disposal of hazardous by-products. Zero Landfill advocates maintain that epidemiologic studies in this sense are not conclusive, being fettered by methodological weaknesses and lack of a serious consideration of confounding factors (Hu and Shy, 2001; Cordioli *et al.*, 2013). As a matter of fact, most of the studies showing adverse effects on human health were actually based on the analysis of older facilities that are to date completely phased-out by new ones.

According to recent literature (Schrenk, 2006; Federico *et al.*, 2010), emission targets imposed by EU Incineration Directive and by stricter national standards on precautionary principle basis would show that the impact above the bottom threshold of a standard urbanized area are almost nil, and the same happens for risk of damages to health (UBA, 2008; WHO, 2007).

This official position is not shared by environmental activists and NGOs, claiming the existence of micro-pollutants conveyed by nanoparticles, while incinerator champions remark the higher nanoparticle emissions of urban traffic, traditional industry, and so forth (Cernuschi, 2013; Buonanno and Morawska, 2015).

Finally, Zero landfill Narrative protest the presumed superiority of pure recycling on integrated methods relying also on waste to energy. From an economic perspective, the increasing marginal costs of MW selection, conjoint with the lower quality of materials collected for higher separation ratios and with imperfections and bottlenecks in the downstream segment of second hand raw materials, suggest that recycling is not a viable option at any cost; extreme recycling scenarios claim a kerbside systems reaching 75% or more of separate collection, a realistic assumption for small cities and rural areas, but not for urban ones (Massarutto, 2015). Jamasb and Nepal (2013) discuss the UK waste management strategy, comparing a ‘‘business as usual’’ setting with the full implementation of the EU waste directive, finding that waste-to-energy is the dominant MW management technique in terms of social cost-benefit.

On this bases, recycling is not a viable solution for all contexts - a point of view that is contrary to that of the Zero Waste option, whose objective is to generalize a source separation level of 80% or more to all communities – addressing the non-recycled quota to incinerators. In this sense, the Zero landfill Narrative stands up to the complementarity of the two MW management solutions, since they address different flows of the same materials; recycling suits those that are easier and cheaper to select, while waste to energy better suits the others (Massarutto, 2015)

According to Complexity theory, besides the aforementioned narratives, another useful tool is the option of Scaffolding Structures (or Scaffolds). As reported in Section 2.3, Scaffolds are organizations of different natures, platforms, scientific and popular science journals, international fairs, mediating between agents and innovation, and carry out the role of supporting agents in facing ontological uncertainty. If Narratives give a medium-long run objective to agents, leading the way to a possible change, Scaffolds back them in the day-by-day relationship with an environment pressured by internal and external change.

The main role of Scaffolds is to strengthen network ties among agents and artifacts through actions such as exploration of options, dissemination, interpretation, and circulation of information, experimentation of solutions, and so on.

In the field of waste management field, we can already identify the existence of relevant Scaffolding Structures. The most prominent one is perhaps the EU LIFE Programme. The LIFE programme is the European Union’s funding instrument for the environment and climate action, aimed at contributing to the implementation, updating and development of EU environmental and climate policy and legislation by co-financing projects with European added value. LIFE began in 1992 and to date there have been four complete phases of the programme (LIFE I: 1992-1995; LIFE II: 1996-1999; LIFE III: 2000-2006 and LIFE+: 2007-2013), while the fifth LIFE phase is next to be inaugurated for the period 2014-2020. The LIFE Programme has always been divided in at least two strands: the first one activated to finance the European nature conservation strategy, and the second one for other environmental projects with the obliged requirements of being replicable in any EU region and prove to be innovative (Silvestri, 2005). In addition, any LIFE financed project must include a communication plan to disseminate the main results achieved. In this sense, EU LIFE Programme is a relevant tool to support experimental projects and to circulate information on new viable products, processes and methods.

Since 1992, numerous LIFE projects have dealt with the technical feasibility and financial viability of methods and technologies to enhance environmental performance in the waste sector. According to the LIFE Programme database[47], from 1992 to 2013 there have been 579 out of 4,171 (13%) financed project focused on waste management issues; 369 of them are related to non-industrial waste, and 101 are identified as “Municipal Waste”.

Nearly half of the LIFE Programme’s beneficiaries have been private firms, underlining the strong economic interest existing in the waste industry.

Prominent MW Scaffolds can be identified in common platforms such as the afore mentioned Zero Waste organization, and in other initiatives implemented by environmental NGOs.

As pointed out in the previous section, Zero Waste is an international network, born in the US and include supranational, national and regional ramifications (13 in Europe), of non-profit associations conveying the Zero Waste Narrative and helping firms and local communities to increase the percentage of recycling and to reduce source waste. The aim of the network is to circulate information, best practices and standards to the community of current and potential members. The Zero Waste Italy organization associates includes a think tank and an established research centre, the Rifiuti Zero Research Center in Capannori (Lucca).

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[47] Website: http://ec.europa.eu/environment/life/project/Projects/index.cfm, retrieved November 25th 2014.

Similarly, many environmental NGOs act as Scaffold in different European Country. This is the case of the Italian Legambiente, that since 1994, has ranked Italian municipalities based on percentage of MW selection achieved and organizes an annual national prize awarded to the most exemplary cities. The prize has garnered relevant fame throughout years, generating a tangible emulation effect among Italian municipalities. In addition to theseparate collection prize, Legambiente publishes many annual reports on the issue of waste (among others, an annual dossier on criminal activities related to environment and waste diversion), and circulates information on the waste issue.

Another important scaffolding role is played by international fairs on waste management. The most relevant in Europe are the biennial fair of Munich (IFAT - International Trade Fair for Environment, Waste Water and Waste Disposal), and the annual fair in Rimini (Ecomondo), while Istanbul's REW Recycling and St. Petersburg's Waste Management - Technology And Equipment fairs are gaining significant importance as well..

Finally, there exist international multidisciplinary journals that disseminate information and update the debate among researchers and practitioners on innovation and technical change in the waste industry.

5.5 Drivers of Innovation in the MW Industry

According to Complexity theory, agents' interaction generates the development of new artifacts and new functions, transforming the existing market system in a new one.

In the previous section, we illustrated four market systems in MW industry characterized by different artifacts. It is worth exploring which kind of dynamics drives the passage from one system to another or, put in another way, which motivations lead interactions to change the artifacts and to generate a new market system.

In an already mentioned study, Nicolli and Mazzanti (2011) focus on technical change in the MW industry, reaching the conclusion that environmental regulation is a relevant driver for it.

Using empirical data from the EPO Worldwide Patent Statistical Database, they observe the existing relationship between environmental policies and patent applications in waste-related technologies over the period 1970-2007, providing interesting insights on the role of policy stringency on the waste management sector. The study shows that policy standards such as national directives on packaging reduction in Denmark, Germany, and Korea greatly impacted the spread of technological change in the sector, offering an indirect suggestion on the active role of policies as an innovation driver. In particular, the older wave of policies, implemented between end of the 1980s and beginning of the 1990s, produced a technological shock in the system, while today their effect is less pronounced in terms of patenting activities, suggesting that the waste sector entered a status of technological maturity. Some of this results had been highlighted before by Mazzanti and Zoboli (2006).

Following this mark, we identify three main policies that stimulated innovation in MW industry in last 30 years: the first one are the national packaging regulations, strengthen in by the EU Beverage Directive (339/1985) and the Second Packaging Directive (62/1994), which introduced *de facto* the Extended Producer Responsibility principle in the EU regulation (see Section 1.3). As a consequence of this set of policies, recycling entered vigorously in local MW agendas, leading to the emergence of new market systems.

A second relevant policy is given by the so called EU Landfill Directive (31/1999), which set stringent technical requirements for landfills and the activities of landfill diversion with the aim of reducing their environmental impact. Among the others conditions, the directive obliged to reduce the amount of biodegradable landfill waste to 35% of 1995 levels by 2016, fostering the innovation related to selection technologies. The implementation of national landfill taxes and the consequent rise in landfill disposal tolls have given a further impulse to a set of artifacts related to both waste-to-energy and recycling market systems, putting the adopting countries progressively on the track of the complete landfill abandonment.

The third policy, again deeply rooted in the EPR principle, is the Waste Electrical and Electronic Equipment Directive (96/2002 amended in 19/2012), that introduced organizational innovations such as the private European Recycling Platform, implemented by four big electronics makers (Hewlett-Packard, Sony, Braun, and Electrolux), working in 2007 with more than 1,000 companies in 30 countries and recycling about 20% of the equipment covered by the WEEE Directive (Nidumolu *et al.*, 2009).

In situations characterized by the implementation of price uniting, a driver of innovation is given by the search for higher productivity by operators. As a matter of fact, the price uniting fosters recycling ratios (see Chapter 4), reducing the revenues from unsorted collection; a way to restore the profit for Collector is to raise productivity thanks to different kinds of innovation.

Finally, a last source of innovation is given by the technology embedded in equipments provided by suppliers. Studying pollution abatement in the pulp industry, Popp and Hafner (2008) find that the innovations only rarely originate from the regulated sector itself. In some of those cases, innovation is in the availability of producers of artifacts normally employed with other functions: this was the case with underground street level dumpsters, a technology proposed to MW industry by constructors of underground garages (see Section 5.1).

Conclusions

In this work we deal with the Municipal (or Solid) Waste management issue from an Industrial Organization perspective. After a brief description of the European MW industry (Chapter 1), and a Literature review on Regulation, Waste management, and Innovation and Technical Change, namely the main economic topics met that make reference for the work (Chapter 2), we introduce three different essays that substantiate the research: in Chapter 3, we develop a theoretical model that illustrated and returned the many nuances characterizing this industry (segmentation, conflicting objectives among agents, coexistence of labour- and capital-intensive activities, spatial issues, and so on); in Chapter 4 we turned to empirics, estimating the theoretical model and searching for the real drivers of MW selection in a representative region of Europe (Lombardy, Italy); in Chapter 5 we finally explored the matter of innovation in a sector wrongly considered as little prone to it.

The MW sector entails many of the characters that Armstrong *et al.* (1994) associate to utility industries: the coexistence of naturally monopolistic activities (the collection segment) with potentially competitive (such as disposing); the foreclosure opportunities for vertically integrated agents, maybe the main reason of the huge wave of mergers (both horizontal and vertical) observed in the European waste industry in last years; the determination of consumers and access prices, both regulated in many regional markets and nowadays subjected to new schemes such as PAYT tariffs (see Chapter 5); the attention for the quality of the service, mainly with respect to health and environmental requirements.

As pointed out by Armstrong *et al.* (1994) with respect to utility industries in the United Kingdom, even for the European industry of MW the degree of competition is still low, due to the presence of vertically integrated operators, poor internationalization and persistence of incumbent advantages enjoyed by former municipalized firms, now converted in public companies still under the rigid control of public bodies.

In addition, we suggest that this conditions are made stronger by the enforcement of PP/SSP (see Chapter 1), that closes the MW industry on regional basis giving potential market power to disposers. Even though PP/SSP do not obstruct the opportunity to implement a competitive market for disposing at the local level, the operating of both the so called NIMBY syndrome (Bottero and Ferretti, 2011) and the technical issues related to the optimum size of disposing facilities make it real that each district could efficiently host just a limited number of plants.

To prevent the exploitation of market power by downstream operators, a social planner, typically a regional authority, is compelled to put into practice a deep and fatiguing regulatory action, with the relevant amount of ineffectiveness costs it entails.

Regulation, waste economics and innovation theory are the three disciplines that serve as theoretical framework for this work (Chapter 2). Our *excursus* in regulation theory put in evidence the focus of this subject on many utility industries (typically telecommunication, electricity, gas and water supply). Probably because not perceived as a network industry, waste management has been totally ignored by regulation and competition studies. This is particularly puzzling, since waste industry in general and MW specifically seem to be characterized by all main subjects of the regulation issue highlighted by Armstrong *et al.* (2007): the optimal regulation of monopoly and former monopolies in a newly liberalized market; the design of practical regulatory policies; the commingling of regulated and competitive agents inside the same market; and, last but not least, the regulation of vertically-integrated industries, with actors operating on both upstream (in MW disposal) and downstream (collection) segments, and circumstances where an agent plays as essential facility to others.

The issues of vertical integration and of the persistence of incumbent's benefits are remarked by Armstrong *et al.* (1994) among the main problems for actual competition in the four mentioned utility industries; as we will see, evidences from a case study identify the same problems in MW industry of Lombardy (Section 4.3.3).

Finally, we discovered that regulation studies applied to utility industries concentrate mainly on competition *for* the market, neglecting the issue of competition *in* the market, that is the subject of the model we develop in Chapter 3, devoted to study from a theoretical perspective the outcomes generated by the relaxation of PP/SSP, in terms of percentage of MW selection, utility of different kinds of agents and, ultimately, social welfare.

As a matter of fact, most of the existing literature on MW and its management has focused on either: (i) the environmental implications of waste and policies to correct welfare distortions (Davies and Doble, 2004; Jenkins *et al.*, 2004; Caplan *et al.*, 2006) or (ii) competition for the market (Demsetz, 1968), according to which natural monopolies can be managed by private firms whose right to operate is entrusted by the government via competitive tendering (Williamson, 1976; Laffont and Tirole, 1993). We focus instead on competition in the MSW market (Porter and van der Linde, 1995; Crocker and Masten, 1996; Massarutto, 2007). The closest contribution to ours is Choe and Fraser (1998), that also model the market for MSW but they focus on the environmental effects of dumping and illegal disposal and on welfare enhancing policy intervention in the sector. Another stream of literature has carefully modelled the MSW sector to analyze the optimal design of MW management programs (Di Corato and Montinari, 2014), but competition is usually not addressed.

The model, that we developed both in a non-spatial and spatial frameworks, provides two main contributions. The first it is to formalise in a simple spatial model the economics of waste collection in the EU. The second is to highlight the main economic effects of EU regulation of the waste sector on market outcomes. In particular, our model confirms that the PP/SSP principles, on which the current EU regulation on waste collection is based, have the effect of limiting competition between disposers. Our main result suggests that an intuitive, "pro-competitive" effect may operate if regulation is abandoned. This intuitive effect, however, has another possible consequence: more competitive disposal markets, reduce the costs of collection and that, in turn, leads to lower incentives to build selection capacity and reduced incentives for households and local councils to engage in separated collection. Regulation, then, may be better suited to encourage recycling and separated collection. The latter effect on separated collection incentives may be one more possible rationale behind the current EU regulation. One view, popularized by Hotelling (1931) and Buchanan (1969), asserts that less competitive market structures may be desirable, in some cases, to limit negative environmental externalities. We highlight a similar effect within a model that captures the complicated structure of the waste collection and disposal sector. The EU policy, in this context, seems to have one more advantage, beyond its usually declared objectives (preventing the creation of pollution havens, above all): increasing the local communities incentives to engage in recycling and separated collection, playing a relevant role in setting a limit to environmental externality. Nonetheless, a compared total welfare analysis shows that other policies, such as the levying of a Pigouvian tax, would be more effective.

Other processing of the model show that any new activity aimed at introducing efficiency gains in the disposal sector (technological innovations that reduce marginal costs, parallel production and trade of energy that add profits, or organizational improvements due to vertical mergers) goes in the same direction of increasing consumer's surplus and producer's profits, but parallel enhancement of unsorted MW and of environmental damage in each territory.

Finally, we show that introducing free trade principles in the market of MW treatment and disposal can indeed provide an incentive in the opposite direction, at least in some circumstances, namely when the perfect symmetry of the model is relaxed: once there exist some forms of discrepancy between territorial areas, so that a district gains an advantage in terms of efficiency, effectiveness or cost reduction in MW management with respect to another district, the free circulation of MW is totally consistent with the objective of a reduction in end-of-the-pipe solutions, and this is true not only when the disposing sector is constrained, so that a part of the original demand for MW diversion is unsatisfied, but even when it is unconstrained and all the unsorted MW can be treated by the chosen facility.

Therefore, the analysis concludes in favour of a mixed system, in which facility owners have a residual obligation to serve the captive market for a flat remuneration, and have the possibility to sell the spare capacity at a higher price, no matter if regulated or market-based. This pricing structure would maximize the incentive to play efforts to boost recycling in the captive market area, while in turn the external area would receive analogous incentive in order to save the disposal cost. This is a relevant result with respect to the debate on the economic efficiency of EU PP/SSP.

In Chapter 4 we have gone inside the correlation between the quota of selected (and the complementary quota of unselected) MW and a set of different variables.

For this reason, we built a data with the cross-section observations of 1,522 municipalities in Lombardy, one of the most populated and the wealthiest region in Italy.

First, we have used the observations to estimate the main functional forms introduced in the theoretical model of Chapter 3, namely the “production function” of selected MW, and the equation that illustrates the relation between unsorted MW and the cost of the service of collection and disposal of it. Both estimations show a very satisfying value for the fitting of the model, but while the correlation between dependent variable and regressors is significant for the first estimation, the opposite happens in the case of unsorted MW.

For this reason we have searched for independent variables of other kinds, and we find that structural, socio-economic, and political variables show significant correlations with selected MW.

The most interesting evidence of the estimation is from political variables. Apart from the implementation of a specific tariff or a general tax, this kind of items are used in the waste field rarely and with no conclusive evidence. Our results advocate a positive and significant correlation between MW selection and the ruling of the municipality by a political-oriented coalition, and that when the government is left-winged the percentage of selection is higher.

Finally, for some regressors the verse of causality between dependent and independent variables is ambiguous a priori, and confounding factors could influence the connection: this could be the case for distance from facility, probably affected by the kind of relationship existing between Collector and Disposer, and for real estate values, possibly pressured by tourism dynamics.

The last part of this work (Chapter 5) has been dedicated to explore a very neglected issue insofar: the presence of innovation and technical change in the MW industry. The standard approach is that, due to its labour-intensive nature, MW management is quite indifferent to innovation, that remains confined to technical advancements of facilities (mostly incinerators with energy recover) in the segment of disposing.

The neoclassical technical change framework, focused on drastic innovation, leapfrogging, and R&D investments, is not the best approach to explore an industry where innovation deals mostly with organizational changes. In this sense, the explanatory contribution of Complexity theory seems higher; concepts such as market system, narrative, scaffolds, are more useful to frame a dynamic in which upgrading and adaptation to regulation are the common drivers of new investment (Massarutto, 2015), whereas innovation is mostly of an incremental kind.

We suggest that it does exist an innovation dynamic in MW industry, even though this dynamic stands on upgrading and adaptation, rather than on drastic changes: pre-paid waste bags system, with or without Radio Frequency Identification transponder, underground city dumps, new door-to-door collection schemes, eco-design of products, Pay As You Throw tariffs, are product, process, and organizational innovations that have changed the MW industry in last years, but their innovative force can be better perceived applying an heterodox approach such as Complexity Theory, with its emphasis on scaffolds, artifacts, market system and narratives (see Chapter 5), rather than mainstream innovation theory.

Summarizing, the main contribution of this research is on one hand to describe the MW sector from an industrial organization perspective, an issue deeply neglected by devoted literature, on the other to analyse the major economic effects of the EU policy and, in particular, the costs and benefits of the PP/SSP provisions. The analysis provides relevant policy implications. First of all, we confirm that the PP/SSP principles on waste collection, limiting competition between disposers, increase the cost of MW collection to the local community; however, we also highlight a subtler consequence of such principles: the higher cost of disposing MW leads households and local councils to exert more effort and, in turn, increase the amount of separated collection, decreasing instead the waste sent for disposal. The latter substitution effect may be a more or less intended consequence of the current EU regulation and it constitutes, perhaps, a further rationale behind the imposition of the PP/SSP. We even show that, under assumptions creating asymmetry between districts, free trade of MW, i.e. the overcoming of PP/SSP, is compatible with an increase in selection and recycling.

Further explorations in MW industrial structure could go in different directions: referring to the model introduced in Chapter 3, the main extensions are in the track of making endogenous the price of collection of the unsorted waste, *p*. A simple way of capturing such a feature in the model is by assuming that the regulator applies a fixed mark-up to set the price of unsorted disposal, e.g. $p = \mu a$ with $\mu > 1$ or, in a more sophisticated framework, to consider another step where collectors compete to win the auction to provide the collection service at the lowest price.

Another interesting change in the model is when we consider in the utility function of inhabitants (i.e. of the Local Council) a "warm glove" effect, namely the intimate reward of behaving as a "good citizen" putting into practice MW selection, and giving a positive contribution to societal goals (Aadland and Caplan, 2006; Cecere *et al.*, 2014). In this case, the sign of *e* could therefore be positive if the latter dimensions compensate the stress of the effort.

The issue of PP/SSP removal could be treated with a game theory model, where the local collector must chose between disposing the MW internally or accepting a probabilistic function of the availability of disposal capacity outside, with the risk to pay an "infinite" cost or fine in case of service default, i.e. the inability of disposing the whole amount of unsorted MW generated.

Finally, we pointed out that innovation and technical change in MW industry are still disregarded topics, deserving a deeper and promising exploration.

And that's it.

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Appendices

A.1 Study of function [3.2.6]

We study the function $q = f(p)$ concentrating on the case of monopoly and generalizing it to other regimes (Bertand and Cournot oligopoly). For this reason, the functional form we adopt is the [3.2.6]:

$$q = \frac{1}{2}\left(1 - \frac{p^2}{8}(\tilde{p} - p)\right)$$

Taking $\tilde{p}$ as given, $q = f(p)$ is a function with an inflexion in $p = \tilde{p}/3$ and a minimum in $p = 2\tilde{p}/3$. As a matter of fact:

$$\frac{dq}{dp} = \frac{p}{8}\left(\frac{3}{2}p - \tilde{p}\right) = 0 \text{, i.e.}$$

$$p_1 = 0,\ p_2 = \frac{2}{3}\tilde{p} \qquad \text{[A1]}$$

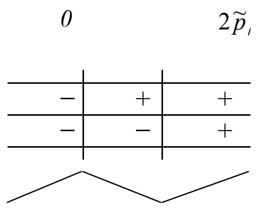

Figure A.1: Study of the slope of [3.2.6]

$$\frac{d^2q}{dp} = \frac{1}{8}(3p - \tilde{p}) = 0 \text{, i.e.}$$

$$p = \frac{\tilde{p}}{3} \qquad \text{[A2]}$$

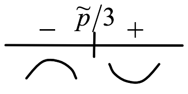

Figure A.2: Study of the slope of [3.2.6]

According to different values of $\tilde{p}$ we have different position of [3.2.6] in the space *q(p)*.

When $\tilde{p}$ is low, *q* never reach the nil value, the inflexion in [3.2.6] is so close to axis *q* that we can assume that *q* almost does not go under the value $q = ½$ and it rapidly raise to $q = 1$.

When $\tilde{p}$ is high, on the contrary, the minimum for *q* would be in a negative region, meaning that selected MW could even reach a 100% quota.

Finally, when $\tilde{p}$ takes intermediate values, q can decrease from the initial value of 50% (corresponding to $p = 0$), but it never will reach $q = 0$.

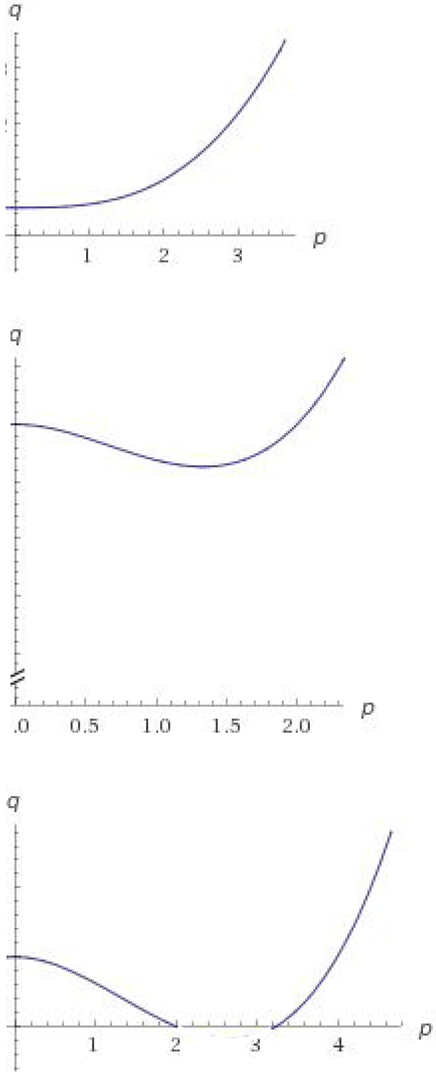

Figure A.3: The diagram of [3.2.6] in case of low, intermediate and high values of $\tilde{p}$ *respectively*

Taking any versions of [3.2.6], we see that increasing values of p generate at the beginning a reduction in q, and – after a minimum – a boost in unselected MW. To understand the reasons of this plot, we must recall equations [3.2.4] and [3.2.5] and verify even how k, e, and d changes with respect to p.

Consider the plot of all of them (plus q) in the case of higher values of $\tilde{p}$: while p increases, the Collector reduces progressively the provision of k, so to replace d with q and enlarge profit. The Local Council (i.e. the households) react raising the effort e, to compensate the lack of k and sustain the production of d.

The move is successful until a threshold value of p, beyond which the provision of k by Collector is so low that the effort to compensate it further is unbearable (remember from [3.1.4] that e is a cost for the Local Council), because from that value p, $|\partial U/\partial p| < |\partial U/\partial e|$.

So, for p higher than that threshold k increases, e declines because of the useless of its action, and d gives space to q, until $d = 0$ and $q = 1$.

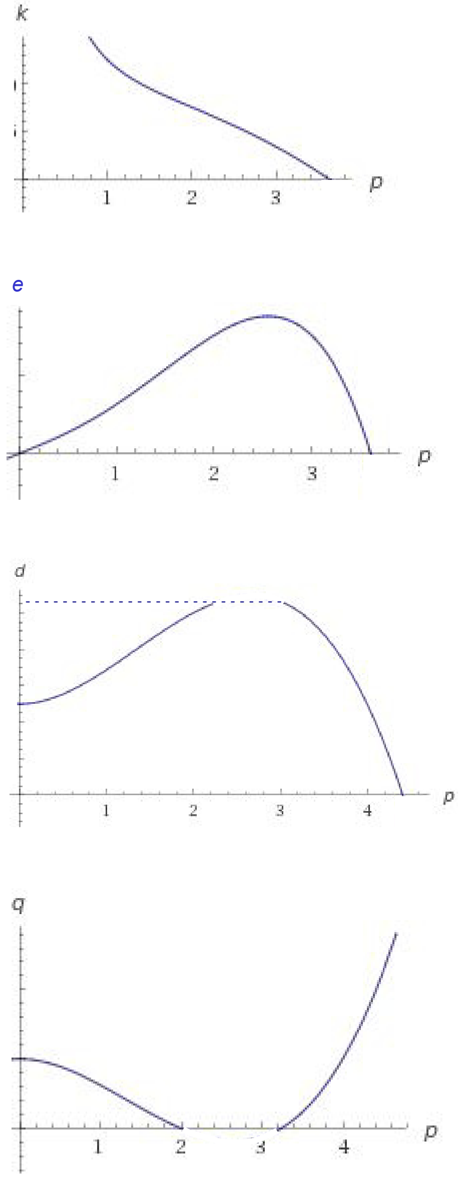

Figure A.4: The diagram of k(p), e(p), d(p), and q(p) with high values of $\widetilde{p}$

We can conclude that for low values of *p*, *q* lowers when *p* grows, while the opposite happens for high values of p.

A.2 The Data set for table [4.1.1]

Municipality	Province	d	q	k	p_tot	e	dens	height	dist	school	wage	inhab_fam	age	house	gov_6	cont	tia	tourism_ratio
Adrara S. Martino	BG	0.62	0.38	12	0.111	0.814	2,158	355	27.45	16.56	11,369	2.52	39.5	925	4	1	0	
Adrara S. Rocco	BG	0.49	0.51	9	0.157	0.829	833	431	28.56	13.27	10,845	2.50	40.9	840	4	1	0	
Albano	BG	0.62	0.38	14	0.165	0.840	8,147	243	13.60	23.84	12,871	2.55	39.4	1,080	1	1	1	-
Albino	BG	0.74	0.26	18	0.179	0.821	18,192	342	19.62	26.21	13,302	2.42	42.5	1,800	5	0	1	
Algua	BG	0.44	0.56	13	0.273	0.822	707	432	21.73	17.36	11,125	2.23	44.8	825	4	1	0	
Almè	BG	0.67	0.33	17	0.206	0.838	5,631	294	9.70	23.57	13,304	2.42	43.9	1,300	5	1	1	-
Almenno S. Bartolomeo	BG	0.66	0.34	17	0.165	0.816	6,062	352	10.55	20.7	12,691	2.48	39.7	1,150	4	1	1	
Almenno S. Salvatore	BG	0.58	0.43	17	0.217	0.813	5,789	328	11.26	23.68	13,117	2.56	43.4	1,150	1	1	1	
Alzano	BG	0.74	0.26	15	0.161	0.823	13,575	304	13.48	28.83	14,321	2.28	42.6	1,700	2	1	1	0.10
Ambivere	BG	0.62	0.38	18	0.240	0.813	2,371	261	8.90	22.88	13,842	2.50	41.9	955	4	0	0	-
Antegnate	BG	0.61	0.39	15	0.256	0.802	3,140	112	23.25	16.58	10,215	2.55	39.4	875	4	1	0	-
Arcene	BG	0.61	0.39	17	0.209	0.836	4,767	152	8.19	25.61	13,137	2.50	41.7	1,075	4	1	0	-
Ardesio	BG	0.33	0.67	10	0.218	0.797	3,583	608	40.87	14.83	10,430	2.42	43.3	910	5	0	0	2.02
Arzago	BG	0.62	0.38	16	0.177	0.817	2,738	106	18.92	27.75	13,651	2.45	41.8	875	4	1	0	
Averara	BG	0.23	0.77	8	0.294	0.703	183	650	37.80	13.48	9,519	1.93	51.1	825	4	1	0	-
Aviatico	BG	0.56	0.44	12	0.280	0.772	526	1022	21.03	17.23	12,691	1.89	46.4	1,095	4	1	0	-
Azzano	BG	0.63	0.37	16	0.211	0.854	7,601	230	5.45	29.74	13,961	2.41	41.9	1,475	4	1	1	
Azzone	BG	0.45	0.55	11	0.318	0.679	426	973	53.78	12.56	10,137	2.09	48.4	770	4	1	0	
Bagnatica	BG	0.62	0.39	17	0.178	0.842	4,211	220	13.82	22.24	13,156	2.44	39.7	1,080	4	1	0	
Barbata	BG	0.57	0.43	12	0.236	0.836	688	105	23.59	15.85	10,290	2.53	40.0	825	4	0	0	-
Bariano	BG	0.67	0.33	16	0.236	0.826	4,361	114	17.03	20.96	12,594	2.53	41.4	875	4	0	0	
Barzana	BG	0.66	0.34	17	0.179	0.845	1,846	300	10.05	21.91	13,075	2.64	38.4	955	4	1	1	-
Bedulita	BG	0.30	0.70	11	0.305	0.749	745	600	16.33	13.49	10,596	2.53	42.6	835	5	1	0	-
Berbenno	BG	0.50	0.51	14	0.181	0.737	2,432	675	18.62	17.21	9,818	2.50	41.5	850	4	1	1	0.21
Bergamo	BG	0.54	0.47	19	0.303	0.814	115,072	249	7.43	47.28	19,086	1.97	45.5	2,450	2	0	1	4.02
Berzo San Fermo	BG	0.48	0.52	13	0.223	0.871	1,304	350	24.53	15.64	10,131	2.67	39.1	870	5	0	0	-
Bianzano	BG	0.82	0.18	12	0.366	0.780	615	600	28.03	16.67	11,241	2.11	45.1	870	2	1	1	-
Blello	BG	0.20	0.80	11	0.246	0.803	72	815	20.72	24.66	8,400	2.18	42.9	745	4	1	0	-
Bolgare	BG	0.64	0.36	17	0.145	0.839	5,906	199	16.31	16.62	11,507	2.69	37.4	930	1	1	1	-
Boltiere	BG	0.60	0.40	16	0.179	0.796	5,880	171	5.70	25.03	13,391	2.41	39.1	1,065	2	1	1	
Bonate Sopra	BG	0.74	0.26	14	0.221	0.808	9,233	230	5.16	21.56	13,627	2.56	38.2	1,010	1	0	1	
Bonate Sotto	BG	0.63	0.37	14	0.174	0.810	6,548	215	4.13	21.65	12,972	2.44	40.4	1,000	1	0	0	
Bossico	BG	0.60	0.40	13	0.346	0.795	980	860	39.60	19.72	11,345	2.67	42.9	790	4	1	0	
Bottanuco	BG	0.58	0.42	15	0.186	0.811	5,180	222	7.65	21.14	12,557	2.51	40.6	980	5	1	1	
Bracca	BG	0.44	0.56	13	0.284	0.802	759	620	21.05	18.62	10,685	2.30	41.6	825	4	1	0	
Branzi	BG	0.29	0.72	9	0.535	0.823	721	874	41.09	17.89	10,441	2.17	45.3	940	4	1	0	10.91
Brembate	BG	0.63	0.37	15	0.211	0.803	8,439	173	6.16	24.06	13,505	2.40	41.5	980	1	0	1	5.41
Brembate Sopra	BG	0.61	0.39	17	0.192	0.812	7,850	267	7.78	23.87	14,847	2.58	42.0	1,400	1	1	0	-
Brembilla	BG	0.52	0.48	14	0.167	0.747	4,130	425	19.28	14.36	11,743	2.53	43.4	825	4	1	0	
Brignano Gera D'Adda	BG	0.59	0.41	15	0.216	0.813	6,000	130	11.89	25.37	13,367	2.49	40.7	875	1	1	0	-
Brumano	BG	0.49	0.51	10	0.180	0.725	105	911	24.29	8.7	9,742	1.72	44.6	835	4	1	0	-
Brusaporto	BG	0.68	0.32	17	0.203	0.863	5,492	255	12.44	26.8	14,365	2.61	37.8	1,080	4	1	0	
Calcinate	BG	0.60	0.41	16	0.223	0.850	5,861	186	15.52	20.42	11,338	2.76	38.2	930	5	1	0	
Calcio	BG	0.54	0.46	15	0.181	0.813	5,411	123	24.69	17.8	10,714	2.64	40.3	875	4	1	0	
Calusco	BG	0.73	0.27	17	0.228	0.791	8,296	273	11.26	19.98	12,774	2.43	43.1	955	3	1	1	
Calvenzano	BG	0.57	0.43	15	0.262	0.813	4,122	113	16.93	26.02	14,229	2.40	42.2	875	1	0	0	-
Camerata	BG	0.34	0.66	6	0.257	0.815	618	570	28.06	14.53	10,438	2.38	43.0	745	4	1	0	

Canonica	BG	0.55	0.45	15	0.237	0.802	4,291	142	9.49	26.87	13,840	2.27	42.1	950	4	1	0	
Capizzone	BG	0.41	0.59	14	0.205	0.732	1,279	454	15.34	18.82	10,186	2.51	41.7	835	5	1	0	-
Capriate	BG	0.61	0.39	17	0.219	0.785	7,821	190	7.13	25.5	14,070	2.32	43.2	1,095	1	1	1	
Caprino	BG	0.52	0.48	12	0.154	0.741	3,122	315	14.29	22.19	12,602	2.39	41.8	955	1	1	1	0.19
Caravaggio	BG	0.60	0.40	17	0.200	0.817	15,905	111	16.95	28.23	13,793	2.35	42.5	1,100	1	1	0	
Carobbio	BG	0.55	0.45	13	0.225	0.851	4,608	232	17.58	19.92	12,039	2.66	37.6	915	4	0	0	
Carona	BG	0.35	0.65	10	0.478	0.842	357	1110	43.65	20.65	14,151	1.75	50.8	940	4	1	0	14.32
Carvico	BG	0.73	0.27	17	0.208	0.807	4,643	287	11.26	20.08	13,325	2.48	42.1	955	2	0	1	
Casazza	BG	0.59	0.41	15	0.194	0.842	4,030	349	26.04	23.1	10,393	2.63	39.9	965	2	0	0	
Casirate	BG	0.56	0.44	14	0.248	0.831	3,954	114	17.18	29.04	13,458	2.43	41.0	875	5	1	0	
Casnigo	BG	0.48	0.53	15	0.174	0.805	3,343	514	27.67	18	12,785	2.42	43.8	970	5	0	0	-
Cassiglio	BG	0.41	0.59	10	0.334	0.844	119	602	35.34	10	9,888	2.16	44.5	745	4	1	0	
Castel Rozzone	BG	0.66	0.34	15	0.147	0.819	2,885	140	10.82	22.21	13,009	2.46	41.1	875	5	1	0	-
Castelli Calepio	BG	0.62	0.38	17	0.159	0.840	9,671	230	23.30	22.62	13,646	2.32	41.4	1,080	5	0	0	
Castione Presolana	BG	0.37	0.63	13	0.247	0.802	3,414	870	46.27	20.56	10,505	2.34	43.1	1,550	4	1	0	18.19
Castro	BG	0.60	0.40	14	0.306	0.836	1,400	200	39.82	37.72	13,588	2.26	45.9	1,175	4	1	0	2.86
Cavernago	BG	0.51	0.49	12	0.131	0.840	2,569	199	12.82	23.71	12,267	2.72	36.6	1,010	4	1	0	
Cazzano	BG	0.48	0.52	14	0.157	0.855	1,620	504	28.37	18.1	12,895	2.57	39.8	835	1	1	0	-
Cenate Sopra	BG	0.63	0.37	15	0.238	0.834	2,511	330	18.38	19.82	12,811	2.65	39.1	1,075	3	1	1	-
Cenate Sotto	BG	0.58	0.42	17	0.174	0.831	3,563	267	18.11	25.42	15,079	2.59	38.3	1,080	4	1	0	
Cene	BG	0.69	0.31	17	0.210	0.813	4,272	368	22.78	19.41	12,845	2.37	42.7	965	1	1	0	
Cerete	BG	0.51	0.49	13	0.229	0.807	1,643	612	38.82	20.33	11,243	2.29	43.5	825	4	1	0	-
Chignolo	BG	0.64	0.36	16	0.260	0.788	3,237	229	6.31	20.52	12,210	2.46	40.0	955	5	1	1	-
Chiuduno	BG	0.62	0.38	15	0.188	0.858	5,886	218	19.07	20.7	12,267	2.56	40.4	930	2		0	-
Cisano	BG	0.55	0.46	15	0.193	0.787	6,304	267	14.71	22.91	13,803	2.47	41.8	955	3	0	1	
Ciserano	BG	0.47	0.54	15	0.299	0.828	5,795	159	6.61	21.72	12,093	2.66	38.6	1,075	5	1	0	
Cividate	BG	0.59	0.41	15	0.185	0.840	5,219	147	20.53	18.47	11,850	2.62	41.4	930	1	1	0	-
Clusone	BG	0.48	0.52	12	0.207	0.816	8,660	648	37.67	27.94	12,889	2.25	44.3	1,650	2	0	0	3.57
Colere	BG	0.29	0.71	9	0.643	0.701	1,139	1013	51.79	11.62	10,816	2.45	42.8	1,145	4	1	0	3.24
Cologno Serio	BG	0.47	0.53	17	0.144	0.834	10,679	156	11.02	21.11	12,160	2.51	39.9	1,015	1		1	
Colzate	BG	0.48	0.52	16	0.151	0.823	1,655	424	27.07	22.16	12,214	2.31	42.5	965	1	0	0	-
Comun Novo	BG	0.66	0.34	15	0.210	0.816	4,277	188	5.22	19.62	12,992	2.54	38.5	995	5	0	1	
Corna	BG	0.35	0.65	5	0.240	0.744	949	736	20.72	16.4	8,318	2.67	38.3	850	4	0	0	
Cornalba	BG	0.49	0.52	9	0.299	0.722	303	893	24.96	15.38	11,572	1.83	48.3	825	4		0	
Cortenuova	BG	0.67	0.33	13	0.268	0.867	1,976	133	18.84	16.76	11,285	2.60	39.2	845	5	1	0	
Costa Mezzate	BG	0.55	0.46	14	0.169	0.847	3,284	218	14.82	22.45	12,283	2.55	38.4	930	4	1	0	-
Costa Serina	BG	0.44	0.56	13	0.225	0.771	983	868	23.03	14.79	11,566	2.23	45.0	855	4	0	0	
Costa Valle Imagna	BG	0.44	0.56	11	0.224	0.732	613	1014	19.05	19.58	9,796	2.15	48.5	890	4	1	0	
Costa Volpino	BG	0.31	0.69	14	0.194	0.822	9,253	248	43.30	24.85	11,792	2.35	43.1	1,050	5	0	0	
Covo	BG	0.54	0.46	13	0.187	0.844	4,076	115	21.04	19.64	11,237	2.62	39.3	845	3	1	0	-
Credaro	BG	0.46	0.54	15	0.187	0.811	3,447	225	25.44	24.12	11,989	2.51	38.2	1,025	1	1	0	
Curno	BG	0.59	0.41	16	0.169	0.846	7,590	244	4.42	32.96	15,021	2.37	43.6	1,800	2		0	
Cusio	BG	0.40	0.60	10	0.384	0.769	250	1040	38.02	9.52	11,660	1.97	50.8	825	4	1	0	
Dalmine	BG	0.66	0.34	18	0.154	0.814	22,948	207	-	29.17	14,434	2.35	41.8	1,375	2	0	0	1.78
Dossena	BG	0.35	0.65	9	0.302	0.801	954	986	26.69	12.28	9,808	2.42	43.9	745	4	1	0	
Endine Gaiano	BG	0.52	0.48	14	0.242	0.782	3,506	382	32.51	21.29	11,110	2.33	43.0	870	4	1	0	0.18
Entratico	BG	0.55	0.45	13	0.196	0.838	1,904	299	21.90	17.02	12,078	2.57	40.1	925	5	1	0	
Fara Gera	BG	0.63	0.37	17	0.152	0.812	7,948	131	11.58	27.26	14,092	2.40	41.5	950	5	1	0	
Fara Olivana	BG	0.71	0.30	14	0.271	0.812	1,289	107	20.50	17.65	10,852	2.50	40.3	875	4	0	0	
Filago	BG	0.58	0.42	17	0.231	0.832	3,168	190	3.94	19.26	12,900	2.51	40.6	875	4	1	0	
Fino del Monte	BG	0.37	0.63	10	0.260	0.818	1,146	700	40.59	25.78	11,414	2.29	44.2	910	4	1	0	4.47
Fiorano al Serio	BG	0.60	0.40	16	0.113	0.860	3,041	396	24.99	21.58	12,594	2.38	42.9	965	4	0	0	-
Fontanella	BG	0.56	0.44	15	0.212	0.810	4,454	105	25.18	19.12	10,470	2.60	40.7	825	3	1	0	-
Fonteno	BG	0.64	0.36	16	0.225	0.754	670	606	34.42	18.02	12,087	2.39	45.2	795	4	1	0	
Foppolo	BG	0.24	0.77	6	0.708	0.718	201	1508	45.29	26.82	13,115	1.81	47.3	1,040	4	1	0	105.47
Foresto	BG	0.42	0.58	12	0.256	0.825	3,137	346	24.98	19.44	11,473	2.60	39.8	870	4	1	0	

Fornovo San Giovani	BG	0.58	0.42	17	0.196	0.833	3,378	109	17.80	21.05	12,276	2.67	39.3	875	5	1	0	-
Fuipiano	BG	0.37	0.63	5	0.264	0.701	220	1019	23.54	27.59	8,498	2.06	45.8	850	4	1	0	
Gandellino	BG	0.41	0.60	11	0.216	0.732	1,041	682	46.37	16.22	11,397	2.22	44.3	910	4	1	0	
Gandino	BG	0.66	0.34	14	0.185	0.808	5,580	552	28.75	21.01	12,384	2.43	44.7	965	5	1	0	-
Gandosso	BG	0.41	0.59	11	0.191	0.824	1,506	488	22.13	22.23	10,407	2.54	40.0	950	1	0	0	
Gaverina	BG	0.57	0.43	14	0.239	0.833	886	509	24.93	16.84	10,077	2.20	43.6	870	4	1	0	
Gazzaniga	BG	0.68	0.32	16	0.213	0.815	5,135	386	23.76	20.94	12,442	2.31	45.5	965	2	1	0	
Gerosa	BG	0.49	0.51	12	0.367	0.754	380	760	22.49	12.94	10,077	2.28	43.5	745	4	1	0	
Ghisalba	BG	0.47	0.53	16	0.212	0.817	6,060	170	13.49	14.87	10,647	2.75	37.9	930	1	0	0	-
Gorlago	BG	0.61	0.39	15	0.172	0.826	5,126	233	17.24	19.08	12,459	2.52	41.4	915	5	1	0	
Gorle	BG	0.76	0.24	17	0.186	0.851	6,550	268	10.16	47.27	19,639	2.42	41.0	1,875	2	0	1	
Gorno	BG	0.37	0.63	9	0.299	0.775	1,638	710	30.02	12.78	11,849	2.14	45.4	835	1	0	0	-
Grassobbio	BG	0.58	0.42	17	0.240	0.836	6,384	225	9.50	24.86	13,512	2.57	39.7	1,200	1	1	1	
Gromo	BG	0.38	0.62	11	0.195	0.780	1,247	676	43.03	22.47	12,029	2.16	45.1	835	4	1	0	14.98
Grone	BG	0.39	0.61	11	0.197	0.798	902	388	25.18	14.57	11,015	2.42	40.7	825	3	1	0	
Grumello	BG	0.61	0.39	15	0.161	0.819	7,351	208	21.24	22.59	13,424	2.67	41.6	1,130	1	1	0	
Isola di Fondra	BG	0.31	0.70	10	0.385	0.759	187	799	38.30	18.71	11,930	1.70	50.7	745	5	1	0	
Isso	BG	0.41	0.59	14	0.175	0.837	666	104	22.64	18.66	11,493	2.66	41.1	825	4	1	0	-
Lallio	BG	0.65	0.35	17	0.196	0.838	4,152	216	2.77	31.66	14,699	2.40	41.0	1,200	4	0	0	
Leffe	BG	0.52	0.48	15	0.168	0.829	4,629	454	27.59	19.69	12,229	2.38	46.2	965	5	1	0	
Lenna	BG	0.35	0.65	6	0.354	0.786	640	482	33.10	25	11,390	2.06	47.1	825	4	1	0	
Levate	BG	0.65	0.35	18	0.182	0.833	3,810	185	3.08	23.62	13,055	2.50	40.7	930	5	1	0	-
Locatello	BG	0.34	0.66	7	0.313	0.742	820	557	21.39	17.53	8,312	2.46	39.5	835	5	1	1	-
Lovere	BG	0.50	0.50	14	0.398	0.814	5,325	208	40.37	37.7	15,006	2.13	47.9	1,275	3	1	0	6.19
Lurano	BG	0.61	0.40	15	0.215	0.818	2,655	147	9.68	24.12	12,985	2.58	39.1	875	4	1	0	-
Madone	BG	0.54	0.46	17	0.204	0.799	3,953	202	4.21	17.49	11,888	2.57	39.4	955	4	1	0	-
Mapello	BG	0.65	0.35	15	0.203	0.825	6,611	250	8.23	22.31	13,119	2.52	40.4	1,100	5	0	1	5.19
Martinengo	BG	0.76	0.24	17	0.171	0.829	10,291	149	15.23	18.07	10,858	2.72	39.4	1,100	1	0	0	-
Medolago	BG	0.70	0.30	14	0.184	0.823	2,352	246	8.70	21.66	12,968	2.55	39.9	955	4	1	1	
Mezzoldo	BG	0.39	0.61	8	0.379	0.640	188	835	40.71	17.41	11,037	1.76	51.7	745	4	1	0	
Misano Gera	BG	0.62	0.38	15	0.202	0.815	2,937	104	19.85	21.86	12,491	2.40	42.0	875	1	0	0	
Moio Calvi	BG	0.38	0.62	11	0.419	0.844	214	654	34.49	29.45	12,297	2.21	46.0	745	4	1	0	
Monasterolo	BG	0.53	0.47	10	0.243	0.807	1,176	365	28.40	19	12,109	2.25	42.9	950	4	1	0	
Montello	BG	0.62	0.38	13	0.178	0.828	3,187	229	15.88	20.81	11,428	2.55	38.2	925	4	1	0	-
Morengo	BG	0.66	0.34	14	0.229	0.826	2,595	126	15.30	23.3	12,875	2.59	40.7	875	4	1	0	-
Mornico Serio	BG	0.75	0.25	15	0.142	0.823	2,866	162	17.21	18.34	11,354	2.55	40.1	995	1	1	1	-
Mozzanica	BG	0.42	0.58	12	0.182	0.849	4,615	102	20.33	22.76	12,199	2.62	40.5	875	4	1	0	
Mozzo	BG	0.49	0.51	15	0.209	0.855	7,496	252	5.54	41.68	18,938	2.43	43.0	1,450	2	1	0	1.80
Nembro	BG	0.68	0.32	17	0.204	0.833	11,595	309	16.40	21.49	12,865	2.39	43.3	1,275	5	1	1	
Olmo al Brembo	BG	0.31	0.70	8	0.332	0.838	512	556	36.12	21.2	11,103	2.11	46.4	745	4	1	0	-
Oltre il Colle	BG	0.43	0.57	8	0.337	0.724	1,050	1030	29.66	15.11	10,553	2.14	46.1	1,005	4	0	0	4.71
Oltressenda	BG	0.23	0.77	7	0.296	0.823	168	737	39.66	26.83	10,745	2.13	48.4	825	4		0	
Oneta	BG	0.38	0.62	9	0.292	0.796	638	740	29.82	16.55	11,885	2.09	47.0	825	4	1	0	-
Onore	BG	0.37	0.64	12	0.336	0.802	853	700	41.49	20.64	12,525	2.00	43.7	935	4	1	0	
Orio	BG	0.37	0.64	16	0.318	0.864	1,762	241	7.50	27.63	12,997	2.37	42.0	1,200	4	1	0	43.92
Ornica	BG	0.33	0.67	8	0.344	0.717	162	922	37.91	11.43	10,633	1.95	49.5	745	4	1	0	
Osio Sopra	BG	0.71	0.29	15	0.219	0.816	5,119	192	2.66	20.7	13,195	2.52	39.4	1,135	5	0	1	
Osio Sotto	BG	0.59	0.41	15	0.251	0.806	12,136	182	3.83	23.96	12,854	2.52	41.2	1,150	1	0	0	0.82
Pagazzano	BG	0.64	0.36	14	0.295	0.831	2,070	126	13.81	22.33	12,045	2.58	41.1	875	4	1	0	-
Paladina	BG	0.69	0.31	15	0.193	0.828	3,993	272	9.08	20.24	14,271	2.39	41.4	1,325	5	1	0	
Palazzago	BG	0.65	0.35	18	0.155	0.802	4,399	397	12.81	22.36	14,500	2.37	39.7	1,150	1		1	0.28
Palosco	BG	0.63	0.37	18	0.203	0.840	5,798	157	19.26	16.14	10,829	2.69	39.7	910	4	1	1	
Parre	BG	0.47	0.54	12	0.152	0.856	2,787	640	33.52	15.32	11,613	2.46	41.1	955	1	1	0	0.79
Parzanica	BG	0.33	0.67	14	0.195	0.705	383	753	34.84	12.8	10,653	1.89	48.8	870	4		0	
Pedrengo	BG	0.68	0.32	16	0.173	0.851	5,946	262	11.43	26.67	13,725	2.52	39.3	1,200	2	0	0	-
Peia	BG	0.54	0.46	9	0.320	0.860	1,832	570	28.38	13.31	10,822	2.48	43.2	910	4	1	0	-

Pianico	BG	0.61	0.39	15	0.296	0.836	1,504	328	38.47	26.51	11,189	2.43	42.0	870	4	1	0	-
Piario	BG	0.31	0.69	9	0.144	0.849	1,114	539	37.19	23.89	12,063	2.47	40.8	825	4	1	0	
Piazza Brembana	BG	0.51	0.49	14	0.214	0.805	1,200	536	33.52	27.96	13,161	2.22	45.2	990	4	0	0	
Piazzatorre	BG	0.32	0.68	9	0.320	0.774	421	868	38.59	24.34	13,102	1.85	50.1	865	4	0	0	25.62
Piazzolo	BG	0.35	0.65	6	0.557	0.757	86	702	37.14	10.98	12,810	2.05	48.6	745	4	1	0	
Pognano	BG	0.54	0.46	14	0.216	0.842	1,614	157	7.52	16.94	12,265	2.58	39.4	910	1	0	0	-
Ponte Nossa	BG	0.34	0.66	11	0.217	0.838	1,888	465	32.39	25.52	12,745	2.10	47.6	910	4	1	0	-
Ponte San Pietro	BG	0.61	0.39	16	0.230	0.819	11,377	224	5.46	32.58	13,767	2.29	44.2	1,350	1	0	1	
Ponteranica	BG	0.73	0.27	15	0.214	0.835	6,805	381	9.98	29.94	15,859	2.35	42.6	1,425	2	0	1	0.20
Pontida	BG	0.51	0.49	16	0.254	0.794	3,221	310	12.37	21.24	13,506	2.42	41.9	955	1	1	0	
Pontirolo	BG	0.58	0.42	14	0.203	0.811	5,012	155	9.27	19.34	13,039	2.46	41.2	950	5	1	0	-
Pradalunga	BG	0.65	0.35	15	0.155	0.825	4,693	327	17.53	21.83	12,466	2.48	41.8	950	2	0	0	
Predore	BG	0.37	0.63	8	0.178	0.833	1,833	190	32.08	24.63	13,773	2.23	43.4	1,350	4		0	11.23
Premolo	BG	0.43	0.57	7	0.186	0.812	1,167	625	32.33	19.1	13,522	2.23	44.2	825	4	0	0	
Presezzo	BG	0.72	0.28	12	0.181	0.844	4,938	236	5.45	27.43	13,529	2.55	41.4	1,135	2	0	0	
Pumenengo	BG	0.49	0.51	13	0.181	0.835	1,736	106	28.01	15.38	9,285	2.76	40.5	825	4	1	0	-
Ranica	BG	0.76	0.24	17	0.210	0.858	6,002	293	11.85	34.54	16,590	2.39	43.8	1,700	5	1	1	
Ranzanico	BG	0.54	0.46	12	0.240	0.798	1,242	519	30.00	22.87	12,826	2.02	44.4	950	4	1	0	1.75
Riva di Sotto	BG	0.59	0.41	14	0.206	0.843	861	186	36.97	25.35	15,105	2.01	47.5	1,175	4	1	0	12.54
Rogno	BG	0.54	0.46	13	0.299	0.838	3,953	215	47.03	23.72	12,581	2.52	40.8	895	3	0	0	
Romano Lombardia	BG	0.56	0.45	17	0.209	0.822	19,371	120	17.81	24.52	12,184	2.48	40.9	1,250	2	0	0	0.31
Roncobello	BG	0.42	0.58	11	0.367	0.788	439	1007	35.98	20.54	11,466	2.18	46.7	825	4	1	0	
Roncola	BG	0.35	0.65	9	0.277	0.742	767	850	13.73	24.8	10,557	2.10	42.6	830	4	1	0	2.83
Rota	BG	0.41	0.59	12	0.283	0.763	946	690	21.45	17.77	9,865	2.09	45.2	830	4	1	0	
Rovetta	BG	0.37	0.63	11	0.218	0.835	4,020	658	40.04	24.28	12,158	2.32	41.6	1,035	5	0	0	0.18
San Giovanni Bianco	BG	0.42	0.58	17	0.347	0.798	5,051	408	25.28	18.75	11,826	2.43	43.2	990	4	0	0	0.11
San Paolo Argon	BG	0.76	0.24	16	0.166	0.845	5,490	255	16.00	23.62	12,908	2.59	38.0	1,105	4		0	
San Pellegrino	BG	0.63	0.37	17	0.203	0.832	4,947	358	21.58	23.02	13,757	2.26	46.0	1,225	4		0	4.14
Santa Brigida	BG	0.40	0.60	11	0.371	0.741	584	805	37.36	8.4	9,136	2.10	47.7	745	4	1	0	
Sant'Omobono	BG	0.41	0.59	12	0.185	0.740	3,443	427	18.50	19.88	10,397	2.38	40.9	925	5	0	0	1.31
Sarnico	BG	0.39	0.61	15	0.227	0.812	6,495	197	27.98	32.58	15,716	2.15	43.6	925	4	1	0	4.69
Scanzorosciate	BG	0.63	0.37	17	0.171	0.841	9,938	279	12.28	29.07	15,068	2.53	42.2	1,125	5	1	0	1.05
Schilpario	BG	0.34	0.66	11	0.221	0.753	1,238	1124	58.63	19.13	11,081	2.10	47.7	1,145	4	1	0	10.68
Sedrina	BG	0.43	0.57	10	0.156	0.784	2,476	328	14.81	13.26	11,728	2.36	43.1	990	5	1	0	
Selvino	BG	0.54	0.46	15	0.268	0.839	1,991	960	18.68	24.48	11,720	2.35	43.2	1,275	4	1	0	9.38
Seriate	BG	0.59	0.41	17	0.184	0.833	24,816	247	10.00	30.49	14,143	2.34	41.5	1,450	3	1	0	0.09
Serina	BG	0.42	0.58	9	0.264	0.756	2,170	820	26.66	19.17	11,005	2.31	45.2	1,065	1	1	0	3.37
Solto Collina	BG	0.59	0.41	15	0.252	0.804	1,763	449	36.10	25.66	12,035	2.38	42.7	1,175	4	0	0	
Solza	BG	0.60	0.40	13	0.254	0.814	1,981	254	9.41	21.02	13,217	2.52	39.2	955	5	1	0	-
Songavazzo	BG	0.33	0.67	10	0.287	0.815	708	640	39.39	23.65	11,212	2.40	42.2	910	4	1	0	-
Sorisole	BG	0.63	0.37	15	0.223	0.814	9,190	415	10.47	21.32	13,058	2.54	41.6	1,750	5	0	1	
Sotto il Monte	BG	0.60	0.40	17	0.164	0.799	4,351	291	10.04	23.58	13,863	2.52	39.8	955	5	1	0	
Sovere	BG	0.59	0.41	14	0.301	0.815	5,420	379	37.71	23.94	10,893	2.51	42.4	895	4	1	0	
Spinone	BG	0.65	0.35	8	0.154	0.843	1,042	360	28.11	21.33	12,026	2.37	41.5	870	3	1	0	3.84
Spirano	BG	0.57	0.44	17	0.208	0.833	5,734	154	8.97	19.09	11,679	2.65	38.6	930	1	0	0	-
Stezzano	BG	0.61	0.40	17	0.169	0.821	12,786	211	3.52	28.16	14,022	2.37	39.7	1,475	2	0	0	7.18
Strozza	BG	0.51	0.50	10	0.217	0.767	1,088	378	13.96	14.48	11,685	2.37	41.3	880	4	1	0	-
Suisio	BG	0.73	0.27	15	0.216	0.815	3,910	234	7.97	18.36	11,903	2.64	40.2	955	4	0	0	-
Taleggio	BG	0.30	0.71	6	0.227	0.724	591	758	27.35	15.15	10,318	1.96	47.7	795	4	1	0	9.86
Tavernola Bergamasco	BG	0.41	0.59	15	0.206	0.871	2,144	191	34.99	22.35	13,939	2.32	45.5	1,150	4	0	0	
Telgate	BG	0.55	0.45	14	0.168	0.833	4,988	191	19.35	18.88	11,426	2.76	39.1	930	1	0	0	
Terno	BG	0.61	0.40	15	0.224	0.795	7,796	229	6.99	25.04	12,314	2.53	37.2	1,010	1	0	1	-
Torre Boldone	BG	0.81	0.19	17	0.153	0.833	8,480	280	10.97	35.53	15,539	2.39	44.0	1,775	2	0	1	
Torre Roveri	BG	0.64	0.36	15	0.181	0.854	2,342	271	13.48	24.04	14,965	2.51	39.9	930	5	1	0	
Torre Pallavicina	BG	0.30	0.70	6	0.221	0.808	1,114	95	30.80	15.12	9,161	2.55	41.8	865	4		0	
Trescore	BG	0.68	0.32	15	0.208	0.831	9,628	305	19.25	25.21	12,727	2.49	40.3	1,065	1	1	0	1.98

Treviglio	BG	0.60	0.40	19	0.233	0.798	28,765	125	13.98	34.94	15,929	2.24	43.6	1,775	2	0	0	0.65
Treviolo	BG	0.68	0.32	18	0.236	0.853	10,404	225	2.81	24.93	14,653	2.47	41.1	1,325	1	1	1	
Ubiale	BG	0.46	0.54	15	0.200	0.809	1,403	336	15.03	14.23	12,426	2.56	42.0	765	5	1	0	
Urgnano	BG	0.70	0.30	18	0.223	0.824	9,655	173	8.79	19.96	12,310	2.58	40.4	1,015	5	0	1	0.59
Valbondione	BG	0.30	0.70	11	0.284	0.725	1,068	900	52.92	14.99	10,393	2.06	45.8	1,005	4	1	0	43.34
Valbrembo	BG	0.54	0.46	13	0.182	0.862	4,002	261	7.76	25.04	14,322	2.47	41.2	1,325	1	0	0	
Valgoglio	BG	0.37	0.63	10	0.212	0.773	611	929	43.45	13.63	10,542	2.32	43.4	865	4	0	0	3.41
Valleve	BG	0.27	0.73	5	0.543	0.788	137	1141	43.52	15.67	11,466	1.96	45.7	855	4	1	0	
Valnegra	BG	0.41	0.59	8	0.568	0.799	209	581	34.04	32.68	14,535	1.99	50.8	810	4	1	0	-
Valsecca	BG	0.42	0.58	13	0.339	0.655	435	627	21.55	9.38	10,810	2.18	43.8	835	4		0	-
Valtorta	BG	0.31	0.69	10	0.374	0.560	290	935	36.93	9.06	9,955	2.12	49.7	795	4	1	0	
Vedeseta	BG	0.40	0.60	7	0.247	0.687	209	820	27.17	15.02	10,324	1.95	52.2	795	4	0	0	
Verdellino	BG	0.48	0.52	15	0.201	0.811	7,683	172	5.32	21.45	11,307	2.56	39.4	1,075	5	1	0	
Verdello	BG	0.57	0.43	14	0.237	0.815	7,794	173	5.28	25.02	13,695	2.44	41.2	1,075	2	0	0	
Vertova	BG	0.47	0.53	16	0.180	0.823	4,839	397	26.36	18.38	12,099	2.39	44.0	965	5	1	0	
Viadanica	BG	0.40	0.60	10	0.162	0.837	1,099	336	28.06	17.18	13,042	2.49	40.3	870	4	1	0	-
Vigolo	BG	0.33	0.67	15	0.175	0.825	598	616	33.51	15.27	11,253	2.38	43.2	850	4	1	0	-
Villa d'Adda	BG	0.68	0.32	16	0.203	0.769	4,753	286	13.20	23.68	9,163	2.58	41.8	955	4	0	1	
Villa d'Aime	BG	0.62	0.38	16	0.221	0.833	6,785	300	11.24	23.71	13,420	2.56	42.5	1,625	5	1	1	2.60
Villa di Serio	BG	0.79	0.21	15	0.190	0.852	6,630	275	13.23	24.44	13,138	2.47	41.0	1,600	5	1	1	
Villa d'Ogna	BG	0.32	0.68	11	0.175	0.833	1,950	542	38.09	21.9	13,572	2.41	42.9	835	1	1	0	-
Villongo	BG	0.50	0.50	15	0.169	0.837	7,708	230	25.38	21.85	11,343	2.65	39.2	1,025	1	1	0	
Vilminore	BG	0.31	0.69	10	0.239	0.759	1,509	1019	54.27	22.56	11,808	2.18	43.6	1,200	4	1	0	0.53
Zandobbio	BG	0.55	0.45	10	0.169	0.832	2,720	278	19.83	16.13	12,074	2.50	40.9	950	5	1	0	
Zanica	BG	0.64	0.37	18	0.226	0.827	8,289	208	6.41	25.26	11,420	2.41	40.2	1,065	5	1	1	0.25
Zogno	BG	0.59	0.42	17	0.220	0.797	9,067	334	16.41	22.6	13,258	2.45	43.4	1,325	1	1	1	
Acquafredda	BS	0.52	0.48	12	0.134	0.824	170	55	28.27	20.05	10,454	2.45	41.0	990	4	1	1	-
Adro	BS	0.72	0.28	15	0.220	0.845	497	271	23.04	19.27	11,729	2.50	42.0	1,750	1	1	1	
Agnosine	BS	0.43	0.58	14	0.148	0.785	134	465	16.98	13.68	12,320	2.42	43.7	875	3	0	0	-
Alfianello	BS	0.37	0.63	8	0.189	0.820	180	48	29.32	18.27	11,362	2.60	43.0	875	5	1	0	-
Anfo	BS	0.35	0.66	11	0.307	0.745	21	400	33.90	20	11,343	2.09	45.3	875	1		0	36.71
Angolo	BS	0.30	0.70	9	0.235	0.790	81	426	41.21	17.56	10,860	2.25	44.7	900	1	1	0	0.69
Artogne	BS	0.45	0.55	14	0.168	0.802	170	266	36.50	18.63	11,619	2.43	41.0	875	5		0	2.69
Azzano	BS	0.56	0.44	17	0.289	0.864	289	95	11.60	21.39	12,767	2.52	37.9	1,200	5		0	
Bagnolo	BS	0.37	0.63	16	0.169	0.834	410	85	11.17	21.62	11,871	2.43	42.4	1,575	2		0	
Bagolino	BS	0.41	0.59	13	0.179	0.782	36	778	37.95	14.66	11,107	2.25	46.6	1,055	4	0	0	7.59
Barbariga	BS	0.40	0.60	15	0.181	0.852	207	81	18.94	23.54	10,167	2.59	41.7	925	4	1	0	-
Barghe	BS	0.46	0.54	7	0.210	0.848	222	295	22.64	21.45	12,319	2.56	41.0	900	4	1	0	
Bassano	BS	0.36	0.64	11	0.204	0.865	237	65	23.28	21.13	12,244	2.48	39.6	1,200	1	0	0	
Bedizzole	BS	0.37	0.63	13	0.148	0.825	453	184	15.37	21.88	11,968	2.51	40.7	1,300	3	0	0	0.80
Berlingo	BS	0.65	0.35	15	0.224	0.855	590	121	14.51	19.25	11,036	2.67	38.6	1,090	4	1	0	-
Berzo Demo	BS	0.29	0.71	14	0.245	0.841	106	790	63.73	22.41	10,507	2.36	44.8	850	4	1	0	
Berzo Inferiore	BS	0.44	0.56	12	0.239	0.837	112	356	45.34	20.16	10,598	2.55	40.7	1,100	5	1	0	-
Bienno	BS	0.61	0.39	15	0.274	0.842	115	445	46.00	25.07	11,445	2.39	44.0	1,150	4		0	0.22
Bione	BS	0.33	0.68	14	0.200	0.762	83	600	18.58	13.36	10,512	2.54	43.2	870	1	1	0	
Borgo S. Giacomo	BS	0.44	0.56	14	0.151	0.824	190	74	28.25	20.7	9,742	2.75	40.9	1,090	2	0	0	-
Borgosatollo	BS	0.77	0.23	17	0.260	0.856	1,083	112	5.00	22.16	12,576	2.46	41.8	1,900	2	0	1	-
Borno	BS	0.34	0.66	13	0.272	0.761	86	912	46.79	23.96	11,746	2.18	46.1	1,750	4	0	0	15.23
Botticino	BS	0.42	0.58	17	0.202	0.855	584	153	5.95	26	13,127	2.43	43.8	2,025	5	1	1	
Bovegno	BS	0.21	0.80	10	0.198	0.688	48	684	30.08	14.83	9,886	2.15	45.7	1,250	5	0	0	
Bovezzo	BS	0.48	0.52	15	0.290	0.861	1,180	203	7.46	32.28	14,420	2.34	43.9	2,425	5	1	1	
Brandico	BS	0.52	0.48	15	0.169	0.817	196	99	15.73	16	10,301	2.61	38.2	1,020	4	1	0	-
Braone	BS	0.35	0.66	13	0.216	0.781	53	394	52.59	25.2	10,777	2.33	43.3	840	4	0	0	
Breno	BS	0.37	0.63	16	0.224	0.826	83	343	48.49	31.39	13,965	2.25	45.1	1,275	5	1	0	4.40
Brescia	BS	0.39	0.61	19	0.214	0.820	2,079	149	-	39.99	16,106	2.03	45.1	3,400	2	0	1	2.73
Brione	BS	0.18	0.82	6	0.207	0.808	102	614	14.43	17.05	11,313	2.18	41.8	870	4	0	0	

Caino	BS	0.31	0.69	15	0.215	0.799	124	385	11.56	20.93	12,179	2.38	39.5	1,250	2	0	0	-
Calcinato	BS	0.33	0.68	15	0.183	0.819	385	171	16.35	21.47	11,311	2.50	39.5	1,525	2	0	1	
Calvagese	BS	0.44	0.56	14	0.207	0.855	297	225	16.63	27.52	12,563	2.42	40.1	1,500	4	1	0	3.26
Calvisano	BS	0.43	0.57	15	0.138	0.844	190	67	21.69	20.33	10,668	2.57	40.1	1,140	3	1	0	
Capo di Ponte	BS	0.38	0.62	14	0.195	0.832	134	362	57.02	24.88	11,296	2.34	43.4	915	5	1	0	0.53
Capovalle	BS	0.24	0.76	5	0.223	0.724	17	960	35.42	14.51	9,454	2.06	49.0	860	4	1	0	
Capriano	BS	0.73	0.27	15	0.222	0.845	335	92	9.26	19.68	12,401	2.49	41.4	1,250	4	1	0	
Capriolo	BS	0.49	0.51	15	0.150	0.811	869	216	26.03	17.51	11,123	2.53	41.2	1,250	4	0	1	1.11
Carpenedolo	BS	0.46	0.55	17	0.174	0.829	427	78	23.89	21.28	11,282	2.65	40.0	1,140	5	1	1	
Castegnato	BS	0.67	0.33	16	0.192	0.874	879	143	9.64	23.67	13,027	2.57	40.1	1,725	5	1	0	
Castel Mella	BS	0.35	0.66	14	0.168	0.845	1,475	106	6.57	16.17	12,922	2.45	39.1	1,500	5	0	0	
Castelcovati	BS	0.67	0.33	15	0.228	0.872	1,075	121	22.05	25.25	9,064	2.70	37.2	1,060	1	0	1	-
Castenedolo	BS	0.65	0.35	17	0.225	0.848	434	152	8.15	22.15	12,797	2.44	41.2	1,325	5	1	1	5.65
Casto	BS	0.41	0.59	9	0.184	0.819	88	417	20.26	16.26	11,209	2.76	40.5	935	3	1	0	
Castrezzato	BS	0.73	0.27	15	0.224	0.820	522	125	19.26	17.44	9,030	2.74	38.7	1,070	2	0	1	
Cazzago	BS	0.76	0.24	17	0.213	0.860	495	200	16.33	18.28	12,092	2.53	41.5	1,325	5	1	1	0.33
Cedegolo	BS	0.40	0.60	10	0.258	0.802	107	413	62.10	24.19	11,283	2.29	44.8	890	5	1	0	0.09
Cellatica	BS	0.53	0.48	16	0.185	0.872	762	170	7.35	34.86	17,230	2.34	44.2	845	5		0	-
Cerveno	BS	0.39	0.61	13	0.207	0.796	30	500	53.67	24.64	11,973	2.25	44.8	845	4	0	0	
Ceto	BS	0.35	0.65	13	0.181	0.830	60	453	54.00	22.55	11,184	2.48	42.1	845	4	0	0	0.42
Cevo	BS	0.39	0.61	9	0.202	0.767	26	1070	62.83	23.1	10,485	1.98	49.8	845	4	1	0	4.00
Chiari	BS	0.38	0.62	15	0.198	0.832	492	148	23.14	24.09	12,104	2.43	42.3	1,975	2	1	1	0.09
Cigole	BS	0.53	0.47	11	0.161	0.835	162	56	24.21	16.68	11,804	2.48	43.7	935	5	1	0	
Cimbergo	BS	0.33	0.67	9	0.184	0.847	21	850	56.53	17.6	11,660	2.12	47.0	860	3	1	0	
Cividate Camuno	BS	0.45	0.55	14	0.214	0.842	816	274	46.59	23.05	11,943	2.42	42.4	865	4	0	0	
Coccaglio	BS	0.79	0.21	16	0.256	0.849	721	162	20.17	25.61	11,786	2.57	39.9	1,325	3	0	1	
Collebeato	BS	0.67	0.34	13	0.281	0.884	876	192	6.41	34.8	16,840	2.38	44.8	2,175	5	1	0	-
Collio	BS	0.06	0.94	2	0.203	0.691	41	850	32.77	15.34	9,597	1.98	44.6	1,005	4	1	0	2.87
Cologne	BS	0.62	0.38	17	0.264	0.858	548	187	23.14	20.92	12,189	2.58	39.9	1,175	5	1	1	
Comezzano-Cizzago	BS	0.25	0.75	14	0.193	0.846	242	107	22.41	14.88	8,757	2.90	36.6	1,010	2	0	0	-
Concesio	BS	0.47	0.54	15	0.168	0.852	788	216	8.96	29.14	14,912	2.28	42.8	2,125	5	1	1	0.06
Corte Franca	BS	0.68	0.32	18	0.174	0.849	509	229	21.94	22.36	13,185	2.40	40.6	1,425	5	0	0	1.07
Corteno	BS	0.20	0.80	8	0.277	0.820	24	925	71.33	16.29	9,707	2.22	43.9	1,040	4	1	0	3.73
Corzano	BS	0.53	0.47	14	0.205	0.821	115	101	19.38	21.1	12,289	2.56	40.5	1,030	4	1	0	
Darfo Boario T	BS	0.39	0.61	15	0.212	0.829	431	218	41.14	29.08	12,272	2.25	42.2	1,475	2	1	1	1.96
Dello	BS	0.42	0.58	15	0.170	0.848	241	84	16.49	20.61	11,224	2.53	39.9	1,350	2	0	0	
Desenzano	BS	0.39	0.61	19	0.236	0.797	450	67	24.74	39.16	15,824	2.07	44.3	3,500	2	0	1	20.84
Edolo	BS	0.53	0.48	14	0.276	0.801	51	699	73.07	28	12,406	2.15	45.1	1,175	5	1	0	4.75
Erbusco	BS	0.71	0.29	16	0.194	0.848	510	236	21.50	23.9	12,881	2.33	40.4	1,450	5	1	1	8.10
Esine	BS	0.49	0.51	14	0.270	0.839	176	286	44.61	23.29	10,876	2.45	41.5	945	5	1	0	
Fiesse	BS	0.68	0.33	12	0.233	0.864	134	39	33.51	14.78	9,296	2.80	42.5	950	2	0	0	-
Flero	BS	0.38	0.63	13	0.186	0.860	875	104	6.28	24.67	13,526	2.41	42.4	1,525	5	0	1	-
Gambara	BS	0.60	0.40	16	0.189	0.837	150	51	30.44	20.21	10,806	2.58	43.2	1,000	3	0	0	
Gardone Riviera	BS	0.32	0.68	17	0.338	0.819	130	71	28.54	36.85	16,060	1.91	46.8	3,500	3	0	0	20.27
Gardone Val Trompia	BS	0.39	0.61	15	0.259	0.826	439	332	19.10	26.22	12,620	2.34	43.1	1,600	5	1	1	
Gargnano	BS	0.29	0.71	14	0.293	0.789	38	66	38.37	26.22	12,344	2.01	48.8	3,225	4	1	0	54.38
Gavardo	BS	0.46	0.54	16	0.198	0.819	402	199	18.24	25.11	12,016	2.46	41.7	1,300	2	0	1	0.36
Ghedi	BS	0.71	0.30	16	0.235	0.827	306	85	14.33	22.91	11,087	2.63	39.6	1,325	2	0	1	0.36
Gianico	BS	0.67	0.33	14	0.251	0.850	165	281	38.12	21.83	10,986	2.46	41.6	900	4	1	0	-
Gottolengo	BS	0.74	0.26	15	0.177	0.810	180	53	26.12	20.71	10,085	2.63	42.8	1,125	3	1	0	
Gussago	BS	0.48	0.52	17	0.134	0.861	659	186	8.52	28.51	14,454	2.39	41.9	2,125	3	0	1	0.32
Idro	BS	0.41	0.59	14	0.174	0.802	86	375	30.31	22.09	11,279	2.28	41.9	1,125	4	0	0	56.16
Incudine	BS	0.38	0.62	9	0.393	0.762	20	910	77.97	21.08	10,277	2.02	47.3	975	4		0	-
Irma	BS	0.06	0.94	1	0.205	0.772	28	804	27.76	14.53	9,154	1.94	45.9	910	4	0	0	-
Iseo	BS	0.62	0.38	16	0.333	0.824	354	198	19.98	34.18	15,179	2.23	44.8	2,650	5	0	1	44.43
Isorella	BS	0.74	0.26	14	0.196	0.848	267	56	25.18	16.36	10,028	2.56	40.5	1,090	2	0	0	

Lavenone	BS	0.21	0.79	8	0.336	0.765	19	385	29.02	17.24	10,153	2.18	46.8	935	4	1	0	
Leno	BS	0.60	0.40	16	0.164	0.828	247	66	16.98	22.01	11,396	2.65	40.5	1,300	5	1	1	0.65
Limone	BS	0.50	0.50	12	0.331	0.845	45	66	53.61	27.35	13,957	2.24	42.6	2,675	4	1	0	856.01
Lodrino	BS	0.34	0.66	7	0.203	0.797	105	725	22.03	15.15	11,340	2.55	41.7	975	4	1	0	
Lograto	BS	0.76	0.24	15	0.216	0.853	307	113	14.29	23.36	11,323	2.59	40.1	1,120	2	0	0	
Lonato	BS	0.42	0.58	17	0.144	0.831	224	188	20.33	28.9	12,902	2.34	41.0	1,950	2	1	1	0.50
Longhena	BS	0.59	0.41	7	0.276	0.851	176	91	16.27	26.12	11,345	2.53	46.1	930	4	1	0	-
Losine	BS	0.31	0.69	10	0.191	0.871	93	391	51.46	26.73	12,574	2.17	43.6	895	4	1	0	-
Lozio	BS	0.30	0.70	7	0.216	0.723	17	975	51.31	12.92	11,047	1.70	49.4	895	4	0	0	
Lumezzane	BS	0.38	0.62	17	0.223	0.781	740	460	13.96	16.97	13,087	2.48	42.7	1,600	2	0	0	-
Maclodio	BS	0.75	0.25	15	0.153	0.860	294	109	15.34	19.94	10,156	2.84	38.2	1,080	4	1	0	-
Magasa	BS	0.11	0.89	2	0.572	0.538	7	970	41.55	9.77	9,883	1.63	56.7	850	4	1	0	0.68
Mairano	BS	0.45	0.55	15	0.233	0.849	293	96	14.24	21.65	11,658	2.53	39.3	1,055	4	0	0	-
Malegno	BS	0.49	0.51	16	0.264	0.780	294	328	47.52	23.23	12,524	2.38	45.0	865	4	1	0	
Malonno	BS	0.36	0.64	13	0.207	0.805	108	596	67.05	20.94	10,345	2.52	44.3	865	5	1	0	
Manerba	BS	0.38	0.62	15	0.234	0.800	176	130	25.84	30.87	14,989	1.98	42.0	3,125	1	0	0	95.26
Manerbio	BS	0.50	0.50	18	0.166	0.830	461	64	20.11	24.78	13,425	2.34	44.0	1,450	2	0	1	
Marcheno	BS	0.30	0.70	14	0.240	0.821	191	372	19.95	20.13	12,880	2.45	41.6	1,070	5	1	0	
Marmentino	BS	0.12	0.88	3	0.322	0.705	38	875	25.96	12.61	10,627	2.09	44.5	810	4	1	0	
Marone	BS	0.54	0.46	15	0.181	0.834	144	189	25.70	22.53	11,967	2.42	43.8	1,300	4	1	0	8.73
Mazzano	BS	0.78	0.22	17	0.326	0.848	745	156	10.65	24.36	12,838	2.39	40.7	1,300	2	0	1	
Milzano	BS	0.49	0.51	11	0.171	0.830	210	49	28.01	18.68	9,980	2.60	39.9	880	3	1	0	-
Moniga	BS	0.39	0.61	16	0.243	0.814	263	125	24.21	28.42	14,515	2.02	42.1	3,025	5	1	0	151.07
Monno	BS	0.33	0.68	9	0.229	0.818	18	1066	76.97	15.02	9,990	1.99	48.6	915	4	0	0	4.89
Monte Isola	BS	0.42	0.58	12	0.361	0.821	145	262	24.17	13.17	10,126	2.40	45.6	2,000	4	1	0	0.51
Monticelli B.	BS	0.76	0.24	9	0.279	0.855	417	283	15.74	28.06	14,505	2.53	40.6	1,325	3	0	0	
Montichiari	BS	0.72	0.28	17	0.201	0.825	299	104	17.65	24.7	12,194	2.48	39.7	1,350	3	1	1	2.01
Montirone	BS	0.47	0.53	14	0.149	0.849	484	100	8.74	18.02	11,351	2.47	38.8	1,200	3	0	0	
Mura	BS	0.38	0.62	9	0.282	0.732	63	691	22.81	10.54	9,948	2.41	42.0	835	4	1	0	
Muscoline	BS	0.34	0.66	13	0.184	0.827	258	272	18.75	22.02	12,506	2.40	40.3	1,200	5	1	1	
Nave	BS	0.41	0.59	16	0.200	0.840	406	236	8.50	22.05	12,792	2.40	43.3	1,400	5	0	0	-
Niardo	BS	0.30	0.70	12	0.206	0.825	89	442	50.83	26.49	13,150	2.43	41.8	845	5	1	0	
Nuvolento	BS	0.65	0.35	13	0.323	0.831	541	176	12.66	20.46	11,648	2.53	41.0	1,250	4	1	0	
Nuvolera	BS	0.35	0.65	17	0.190	0.849	342	165	11.07	23.07	11,864	2.55	40.1	1,250	4	1	1	
Odolo	BS	0.43	0.57	13	0.205	0.758	327	345	18.08	19.88	12,043	2.61	40.8	940	4	0	1	
Offlaga	BS	0.54	0.46	14	0.199	0.831	186	74	17.70	21.12	10,727	2.68	40.2	1,070	5	0	0	-
Ome	BS	0.34	0.66	12	0.176	0.872	327	231	14.07	20.98	12,516	2.45	42.6	1,425	5	1	0	5.90
Ono San pietro	BS	0.29	0.71	15	0.219	0.828	71	516	55.29	17.53	10,779	2.45	41.6	865	4	1	0	
Orzinuovi	BS	0.58	0.42	18	0.253	0.823	263	88	27.39	28.42	12,617	2.47	41.6	1,950	5	0	1	
Orzivecchi	BS	0.49	0.51	14	0.198	0.862	254	91	23.61	21.66	10,536	2.60	41.9	1,065	5	0	0	
Ospitaletto	BS	0.30	0.70	15	0.193	0.837	1,633	154	11.93	22.62	12,140	2.33	39.4	1,700	5	0	1	-
Ossimo	BS	0.24	0.76	10	0.286	0.809	97	869	46.85	22.68	10,566	2.04	44.4	845	4	0	0	
Padenghe	BS	0.48	0.52	15	0.303	0.830	212	127	21.79	39.01	16,433	2.05	43.4	3,300	5	0	0	27.92
Paderno Franciacorta	BS	0.73	0.27	15	0.213	0.857	672	186	13.42	25.32	12,650	2.53	40.5	1,325	5	1	0	
Paisco	BS	0.34	0.66	7	0.210	0.741	5	853	61.82	16.89	11,059	1.97	48.8	855	4	1	0	
Paitone	BS	0.33	0.67	15	0.193	0.852	271	177	13.96	19.9	10,563	2.48	40.8	1,200	4	1	0	
Palazzolo sull'Oglio	BS	0.40	0.60	18	0.197	0.833	857	166	27.14	25.48	12,562	2.36	41.6	1,750	2	1	1	0.33
Paratico	BS	0.34	0.67	14	0.221	0.836	720	234	25.48	24.83	13,028	2.33	40.8	1,375	5	1	0	7.27
Paspardo	BS	0.33	0.67	8	0.273	0.801	61	978	57.37	25.87	11,990	2.12	47.5	865	3	1	0	
Passirano	BS	0.78	0.22	17	0.241	0.855	512	210	14.96	26.66	13,807	2.39	41.9	1,300	5	1	1	0.20
Pavone	BS	0.49	0.51	11	0.164	0.848	241	54	24.63	19.38	10,554	2.64	42.7	1,055	3	1	1	-
Pertica Alta	BS	0.29	0.72	8	0.279	0.708	28	900	25.84	12.09	11,414	2.08	47.8	835	1	0	0	
Pertica Bassa	BS	0.32	0.68	11	0.240	0.759	22	511	27.82	12.46	10,107	2.26	45.4	835	4	1	0	
Pezzaze	BS	0.12	0.88	4	0.272	0.731	72	620	27.96	12.37	10,597	2.25	44.4	940	4	1	0	
Pian Camuno	BS	0.39	0.61	14	0.185	0.813	401	244	35.95	19.56	10,710	2.43	40.0	965	4	1	0	
Piancogno	BS	0.26	0.74	14	0.220	0.808	349	250	43.92	24.65	10,907	2.45	41.5	865	1	1	0	2.12

Pisogne	BS	0.68	0.32	18	0.277	0.795	170	187	33.06	23.27	12,573	2.28	44.2	1,200	5	1	1	2.28
Polaveno	BS	0.79	0.21	11	0.276	0.777	288	568	17.15	15.65	12,339	2.51	41.7	1,090	2	1	0	
Polpenazze	BS	0.41	0.59	17	0.276	0.826	284	204	21.81	25.91	14,547	2.16	43.0	2,225	2	1	0	1.14
Pompiano	BS	0.39	0.61	15	0.120	0.870	260	93	21.21	21.56	11,301	2.65	40.8	990	2	0	0	-
Poncarale	BS	0.46	0.54	14	0.199	0.886	422	100	8.11	21.67	12,381	2.55	40.0	1,250	4	0	0	
Ponte di Legno	BS	0.27	0.73	11	0.286	0.842	18	1257	84.46	28.71	12,837	1.99	46.2	3,500	5	1	0	74.31
Pontevico	BS	0.70	0.30	13	0.200	0.786	244	55	29.75	18.91	11,477	2.57	43.8	1,020	2	0	1	1.53
Pontoglio	BS	0.33	0.67	13	0.218	0.839	615	155	29.51	20	10,558	2.52	40.8	1,125	3	1	1	-
Pozzolengo	BS	0.59	0.41	17	0.234	0.812	161	135	34.29	20.39	11,490	2.54	42.9	1,500	4	1	0	15.15
Pralboino	BS	0.61	0.39	11	0.189	0.805	172	47	28.83	24.65	10,921	2.46	42.9	1,040	5	0	0	
Preseglie	BS	0.35	0.65	14	0.181	0.796	135	391	20.72	18.39	12,512	2.48	42.3	990	4	1	0	-
Prestine	BS	0.30	0.70	8	0.327	0.796	24	610	45.44	15.9	10,039	1.97	47.2	845	4	1	0	
Prevalle	BS	0.82	0.18	17	0.183	0.816	701	186	15.47	19.23	10,545	2.63	38.9	1,500	2	0	0	
Provaglio d'Iseo	BS	0.73	0.27	17	0.272	0.848	446	230	18.76	22.61	12,705	2.44	40.7	1,475	5	1	1	0.72
Provaglio Val Sabbia	BS	0.19	0.81	8	0.194	0.808	63	678	24.31	14.09	11,267	2.57	42.6	1,475	3	1	0	
Puegnago	BS	0.63	0.37	17	0.256	0.810	309	224	22.49	28	12,712	2.36	42.9	2,150	2	1	0	3.24
Quinzano	BS	0.72	0.28	16	0.212	0.837	296	65	29.27	19.61	11,623	2.46	43.4	1,125	5	1	0	
Remedello	BS	0.46	0.54	14	0.131	0.834	156	47	29.63	22.96	10,710	2.62	41.4	1,080	4	1	0	-
Rezzato	BS	0.74	0.26	17	0.342	0.834	715	147	7.07	29.15	13,778	2.26	43.2	1,800	5	1	1	2.11
Roccafranca	BS	0.38	0.62	14	0.180	0.864	250	117	25.28	17.15	9,777	2.73	43.6	990	1	0	0	-
Rodengo-Saiano	BS	0.41	0.59	15	0.208	0.859	705	176	12.50	28.6	14,268	2.41	38.0	1,800	2	0	1	
Roè	BS	0.45	0.55	17	0.197	0.807	789	240	22.54	26.83	14,018	2.32	40.2	1,550	5	1	0	0.54
Roncadelle	BS	0.70	0.30	17	0.248	0.849	1,027	118	5.72	26.43	12,598	2.40	40.8	1,475	5	1	1	
Rovato	BS	0.67	0.33	17	0.223	0.819	707	192	18.27	22.74	12,050	2.38	39.5	1,825	5	1	1	0.06
Rudiano	BS	0.67	0.33	17	0.322	0.846	586	117	26.80	17.89	9,607	2.71	38.4	1,050	5	1	0	
Sabbio Chiese	BS	0.38	0.62	15	0.174	0.799	208	279	21.16	18	12,196	2.52	40.7	1,090	5	1	0	
Sale Marasino	BS	0.46	0.54	16	0.229	0.834	209	200	21.74	22.94	13,115	2.34	46.6	1,500	5	1	0	1.52
Salò	BS	0.31	0.69	16	0.250	0.798	355	75	25.43	35.61	15,592	2.14	45.2	3,600	3	1	0	15.94
San Felice Benaco	BS	0.47	0.53	16	0.231	0.826	128	109	26.26	34.74	13,862	2.21	44.8	3,025	3	0	1	23.83
San Gervasio BS	BS	0.42	0.59	8	0.164	0.828	237	57	24.95	20.82	10,753	2.45	37.1	940	5	0	0	
San Paolo	BS	0.47	0.54	12	0.197	0.855	244	77	23.19	18.2	9,844	2.72	40.0	965	4		0	
San Zeno	BS	0.44	0.56	15	0.167	0.867	755	112	3.65	24.73	13,485	2.29	41.6	1,500	2	1	0	-
Sarezzo	BS	0.36	0.64	15	0.176	0.842	775	273	15.42	21.89	12,446	2.48	41.1	1,650	5	1	0	
Saviore Adamello	BS	0.30	0.70	8	0.262	0.780	12	1210	63.23	18.15	10,581	2.00	49.5	865	5	1	0	1.08
Sellero	BS	0.33	0.67	14	0.238	0.827	107	476	59.69	20.3	10,667	2.36	43.6	865	5	0	0	
Seniga	BS	0.43	0.57	14	0.234	0.813	115	48	59.69	18.27	11,462	2.45	44.9	985	4	1	0	-
Serle	BS	0.31	0.69	15	0.255	0.763	168	493	11.93	12.62	10,192	2.32	43.3	1,375	5	1	0	
Sirmione	BS	0.48	0.52	18	0.225	0.799	221	66	30.10	31.14	14,671	1.81	43.1	4,050	2	1	1	153.52
Soiano	BS	0.44	0.56	15	0.225	0.851	307	196	22.22	35.84	16,558	1.95	42.7	2,625	2	1	0	15.08
Sonico	BS	0.39	0.61	13	0.244	0.849	21	650	71.92	23.26	11,544	2.22	45.4	865	3	1	0	4.46
Sulzano	BS	0.53	0.47	17	0.312	0.810	182	200	20.83	28.85	13,430	2.02	41.7	1,500	4	1	0	6.71
Tavernole	BS	0.10	0.90	4	0.263	0.816	69	475	24.73	18.77	11,411	2.29	44.5	940	4	0	0	
Temù	BS	0.21	0.79	9	0.335	0.843	26	1144	82.62	22.98	11,109	2.20	43.8	2,300	5	1	0	41.20
Tignale	BS	0.34	0.66	13	0.318	0.803	26	555	45.34	23.07	10,201	2.08	47.2	1,900	5	1	0	163.80
Torbole	BS	0.32	0.69	16	0.153	0.844	491	112	8.81	23.23	11,960	2.55	39.2	1,200	5	1	0	
Toscolano-Maderno	BS	0.35	0.65	16	0.260	0.813	143	86	32.07	27.99	12,827	2.12	46.5	3,075	3	1	1	49.75
Travagliato	BS	0.76	0.24	17	0.280	0.833	765	129	11.44	17.44	11,077	2.48	40.1	1,625	5	0	1	
Tremosine	BS	0.33	0.67	15	0.298	0.819	30	414	49.49	18.51	10,822	2.29	43.5	1,900	5	0	0	118.00
Trenzano	BS	0.76	0.24	15	0.298	0.852	276	108	17.67	14.25	9,594	2.76	39.0	1,325	2	0	0	-
Treviso BS	BS	0.24	0.76	10	0.245	0.752	31	687	27.69	18.24	9,168	2.81	44.6	835	4	0	0	
Urago d'Oglio	BS	0.56	0.44	16	0.283	0.844	359	131	27.87	16.85	9,741	2.59	39.4	1,080	1	0	1	-
Vallio	BS	0.45	0.55	14	0.214	0.813	95	304	16.26	18.8	12,519	2.34	41.0	1,065	5	1	1	0.97
Valvestino	BS	0.29	0.71	6	0.428	0.614	7	680	38.83	12	10,154	1.73	57.2	800	4	1	0	
Verolanuova	BS	0.48	0.52	15	0.166	0.854	316	64	24.85	23.84	12,576	2.54	42.8	1,150	2	1	0	
Verolavecchia	BS	0.55	0.45	15	0.183	0.850	185	68	25.68	20.25	12,440	2.42	44.7	1,080	5	1	0	
Vestone	BS	0.42	0.58	14	0.192	0.796	347	319	24.45	22.95	12,114	2.54	41.8	1,090	2	0	0	

Vezza d'Oglio	BS	0.25	0.75	7	0.274	0.823	27	1080	80.40	27.7	12,041	2.22	42.7	1,925	4	1	0	1.56
Villa Carcina	BS	0.41	0.60	15	0.167	0.830	757	249	11.89	22.51	12,824	2.39	43.0	865	2	0	0	-
Villachiara	BS	0.76	0.24	15	0.174	0.870	87	75	29.83	13.84	10,421	2.59	41.2	865	5	1	0	-
Villanuova sul Clisi	BS	0.33	0.67	15	0.210	0.822	628	216	19.43	25.37	12,934	2.28	43.4	1,250	5	1	0	-
Vione	BS	0.27	0.73	9	0.372	0.783	20	1250	82.24	19.15	10,910	2.14	49.1	1,850	4	0	0	
Visano	BS	0.70	0.30	13	0.194	0.891	177	60	25.59	20.47	11,690	2.79	39.9	965	4	0	0	
Vobarno	BS	0.28	0.72	15	0.233	0.798	153	241	25.04	18.63	11,191	2.35	43.0	1,200	5	1	1	
Zone	BS	0.46	0.55	13	0.296	0.792	56	684	27.91	14.83	11,512	2.10	46.0	1,200	5	0	0	14.67
Albavilla	CO	0.56	0.44	20	0.223	0.758	599	429	7.63	30.53	14,738	2.16	44.2	1,300	2	0	1	
Albese Cassano	CO	0.57	0.43	20	0.159	0.784	521	402	6.13	27.43	14,684	2.43	45.6	1,300	4	0	1	
Albiolo	CO	0.51	0.49	13	0.219	0.763	943	423	11.48	24.4	10,007	2.47	40.1	1,225	4	0	1	-
Alserio	CO	0.63	0.37	16	0.251	0.809	631	265	9.38	25.86	14,226	2.60	40.7	1,175	4	1	0	-
Alzate Brianza	CO	0.63	0.37	16	0.228	0.789	659	371	8.59	25.71	14,244	2.51	42.0	1,175	3	1	0	
Anzano	CO	0.63	0.37	16	0.193	0.818	541	329	9.56	28.24	15,456	2.48	42.7	1,175	4	1	0	
Appiano gentile	CO	0.43	0.57	13	0.249	0.743	601	366	10.42	30.55	15,797	2.44	44.4	1,450	4		0	1.13
Argegno	CO	0.35	0.65	13	0.384	0.827	157	210	15.12	32.21	14,924	1.92	45.6	1,500	4	1	0	18.10
Arosio	CO	0.59	0.41	13	0.219	0.796	1,852	292	13.92	27.49	13,580	2.53	42.5	1,275	2	1	0	
Asso	CO	0.39	0.61	9	0.231	0.716	565	427	15.21	26.33	12,620	2.42	42.8	1,100	5	1	0	-
Barni	CO	0.25	0.75	8	0.191	0.816	101	627	17.78	26.3	11,123	2.13	42.2	880	3	1	0	-
Bellagio	CO	0.37	0.63	11	0.451	0.762	116	229	22.61	26.39	13,515	2.22	46.3	1,575	4		0	58.81
Bene Lario	CO	0.30	0.70	8	0.185	0.776	61	377	25.46	8.24	6,171	2.42	40.8	800	4	1	0	
Beregazzo	CO	0.64	0.36	18	0.226	0.778	706	423	11.58	21.97	11,629	2.48	42.4	1,225	4	1	0	-
Binago	CO	0.70	0.31	15	0.221	0.770	684	431	13.17	23.46	10,939	2.42	41.1	1,225	4	0	0	-
Bizzarone	CO	0.54	0.46	15	0.198	0.731	551	436	19.12	23.48	9,135	2.40	42.4	1,200	4	1	0	
Blessagno	CO	0.23	0.77	5	0.205	0.727	79	762	16.63	15.69	9,698	2.16	43.8	800	4	1	0	
Blevio	CO	0.40	0.60	8	0.208	0.750	203	231	3.86	34.01	15,794	2.07	45.1	1,700	4	0	0	14.15
Bregnano	CO	0.64	0.36	16	0.293	0.767	1,013	298	13.46	25.48	13,734	2.48	41.1	1,250	2	0	1	-
Brenna	CO	0.63	0.37	16	0.217	0.820	423	356	10.71	22.67	14,009	2.59	42.5	1,100	4	1	0	-
Brienno	CO	0.56	0.44	14	0.417	0.773	44	203	11.54	33.81	13,802	2.24	43.7	1,325	5	1	0	
Brunate	CO	0.36	0.64	13	0.431	0.763	900	715	1.35	42.69	16,070	2.28	43.8	1,575	4	0	0	4.54
Bulgarograsso	CO	0.59	0.41	12	0.163	0.796	1,021	317	9.38	22.45	13,354	2.51	40.4	1,350	4	0	0	-
Cadorago	CO	0.67	0.33	15	0.252	0.778	1,103	313	9.94	29.14	14,272	2.38	41.1	1,850	3	1	0	-
Caglio	CO	0.32	0.68	14	0.182	0.756	69	800	13.61	26.1	14,338	2.05	47.3	880	4	1	0	
Cagno	CO	0.66	0.34	16	0.255	0.749	582	405	16.00	20.19	9,889	2.47	41.8	880	4	1	1	-
Campione d'Italia	CO	0.29	0.71	13	0.818	0.718	818	273	19.78	43.08	32,859	1.96	46.5	3,525	4	0	0	
Cantù	CO	0.65	0.35	17	0.200	0.746	1,694	369	9.83	31.17	13,902	2.41	43.0	1,500	2	1	0	0.49
Canzo	CO	0.47	0.53	15	0.233	0.728	459	402	15.35	28.38	13,212	2.28	44.9	1,200	2	0	0	0.66
Capiago Intimiano	CO	0.50	0.50	21	0.254	0.791	977	421	5.52	33.33	15,765	2.52	43.0	1,425	5	1	1	
Carate Urio	CO	0.60	0.40	13	0.395	0.783	174	204	7.39	34.22	22,400	2.07	46.9	1,875	4	1	0	4.48
Carbonate	CO	0.61	0.40	17	0.137	0.810	568	267	4.17	28.82	15,110	2.50	43.9	1,150	3	1	0	
Carimate	CO	0.65	0.35	16	0.308	0.811	843	265	12.00	38.66	18,918	2.47	41.8	1,475	4	1	0	2.91
Carlazzo	CO	0.26	0.74	11	0.182	0.742	238	481	27.08	18.38	6,050	2.38	41.5	1,000	3	1	0	12.47
Carugo	CO	0.60	0.40	13	0.214	0.816	1,505	270	14.11	28.15	13,317	2.49	41.5	1,275	1	0	0	
Casasco	CO	0.24	0.76	11	0.356	0.687	108	822	14.91	33.84	11,415	1.97	46.4	1,025	4	1	0	-
Caslino d'Erba	CO	0.52	0.48	14	0.198	0.733	248	427	11.60	25.48	14,495	2.33	43.4	880	4	1	0	-
Casnate Bernate	CO	0.43	0.57	14	0.253	0.815	918	342	6.07	36.64	16,197	2.46	43.0	1,375	2	1	0	
Cassina Rizzardi	CO	0.50	0.50	13	0.203	0.790	929	317	14.07	33.93	18,701	2.32	40.8	1,350	4	0	0	-
Castelmarte	CO	0.53	0.47	15	0.159	0.800	659	459	11.55	28.81	14,069	2.49	41.8	1,000	4	1	0	-
Castelnuovo Bozzente	CO	0.68	0.32	18	0.265	0.824	247	398	10.29	24.31	11,587	2.45	41.6	1,150	3	1	0	-
Castiglione d'Intelvi	CO	0.25	0.75	10	0.228	0.734	255	650	35.65	23.7	10,644	2.25	40.7	1,100	4	1	0	15.06
Cavargna	CO	0.16	0.84	6	0.260	0.533	16	1071	31.22	5.75	2,170	2.10	47.7	800	4	1	0	
Cermenate	CO	0.75	0.25	15	0.133	0.787	1,125	297	11.92	27	14,365	2.40	43.1	1,875	3	1	0	
Cernobbio	CO	0.55	0.46	13	0.343	0.774	580	201	3.83	36.12	19,953	2.10	46.9	2,325	2	1	1	16.80
Cirimido	CO	0.64	0.36	14	0.277	0.766	805	290	13.54	25.06	13,396	2.54	42.5	1,225	4	1	0	-
Civenna	CO	0.28	0.72	10	0.270	0.779	143	627	20.29	29.48	16,942	1.94	48.0	1,050	4		0	
Claino Osteno	CO	0.35	0.66	8	0.271	0.664	40	280	21.97	18.32	6,475	2.07	46.8	900	4		0	

Colonno	CO	0.35	0.65	13	0.371	0.817	90	215	17.20	27.29	11,188	2.00	45.4	1,400	4	1	0	-
Como	CO	0.37	0.63	16	0.302	0.733	2,234	201	-	40.7	16,300	2.07	45.8	3,300	2	1	0	5.35
Corrido	CO	0.24	0.76	8	0.207	0.749	134	483	26.70	15.51	4,876	2.49	40.5	825	4	1	0	
Cremia	CO	0.32	0.68	13	0.255	0.756	70	323	33.85	14.15	8,982	2.32	45.9	1,000	4	1	0	
Cucciago	CO	0.60	0.40	14	0.272	0.785	690	349	7.86	26.62	13,599	2.46	42.1	1,425	4	1	0	-
Cusino	CO	0.13	0.87	8	0.213	0.767	24	800	29.89	13.18	6,651	2.18	47.2	800	4	1	0	
Dizzasco	CO	0.25	0.75	10	0.275	0.656	161	506	14.92	34.25	14,070	2.28	49.3	1,000	3	1	0	-
Domaso	CO	0.22	0.78	10	0.264	0.810	241	216	42.59	30.68	13,171	2.07	46.4	1,125	4	0	0	95.92
Dongo	CO	0.39	0.61	14	0.104	0.785	458	208	38.79	23.55	11,459	2.28	46.3	1,400	4	0	0	12.37
Drezzo	CO	0.65	0.35	13	0.251	0.776	656	285	16.30	23.49	10,393	2.38	41.6	1,300	1	1	0	
Erba	CO	0.61	0.40	17	0.322	0.770	913	320	11.13	33.49	15,627	2.36	45.3	2,000	2	0	0	1.81
Eupilio	CO	0.42	0.58	13	0.205	0.806	423	383	14.15	30.07	16,821	2.45	42.5	1,300	4		0	
Faggeto Lario	CO	0.28	0.72	7	0.421	0.685	68	533	7.77	30.55	14,383	2.16	44.0	1,550	4	1	0	3.10
Faloppio	CO	0.54	0.46	15	0.198	0.769	1,059	376	16.95	22.2	10,155	2.48	41.0	1,250	4	1	0	-
Fenegrò	CO	0.59	0.41	14	0.215	0.777	583	290	13.81	25.53	14,439	2.45	40.8	1,225	4	1	0	-
Figino Serenza	CO	0.57	0.43	16	0.232	0.782	1,062	329	19.21	22.89	12,649	2.58	42.1	1,425	5	1	0	
Fino Mornasco	CO	0.49	0.51	14	0.272	0.765	1,344	334	8.09	27.76	13,716	2.57	41.6	1,425	5	1	1	
Garzeno	CO	0.30	0.70	12	0.207	0.721	29	662	38.16	5.68	8,965	2.16	50.6	710	4	1	0	
Gera Lario	CO	0.26	0.74	11	0.200	0.802	152	201	45.61	26.55	12,044	2.17	43.2	1,175	4	0	0	
Gironico	CO	0.59	0.41	15	0.331	0.792	504	370	14.81	16.06	12,111	2.61	41.3	1,450	5	1	0	
Grandate	CO	0.57	0.43	14	0.228	0.810	1,049	324	5.52	26.22	15,447	2.42	45.2	1,425	4	1	0	19.64
Grandola	CO	0.26	0.74	10	0.186	0.722	76	443	25.79	31.9	8,850	2.27	44.0	1,000	4	1	0	6.77
Gravedona	CO	0.33	0.67	15	0.232	0.784	103	201	40.91	20.52	12,032	2.18	46.2	1,400	4	1	0	11.82
Griante	CO	0.41	0.59	10	0.234	0.827	103	247	23.57	26.08	11,974	2.12	48.3	1,750	4	1	0	370.61
Guanzate	CO	0.58	0.42	16	0.256	0.780	832	342	12.04	29.89	15,275	2.48	41.2	1,300	3	1	0	
Inverigo	CO	0.68	0.32	16	0.202	0.789	908	346	12.91	32.61	15,015	2.39	42.5	1,800	2	1	0	
Laglio	CO	0.62	0.38	13	0.248	0.768	151	202	9.61	31.68	14,756	2.13	45.7	1,925	4	0	0	9.14
Laino	CO	0.39	0.62	10	0.522	0.768	77	671	19.45	21.85	8,785	2.15	44.4	925	4	1	1	-
Lambrugo	CO	0.61	0.40	15	0.255	0.813	1,292	280	13.10	27.69	14,853	2.33	42.8	1,125	5	1	0	-
Lanzo d'Intelvi	CO	0.28	0.72	14	0.265	0.686	144	907	19.91	28.74	10,832	1.87	47.8	1,050	3	0	0	16.61
Lasnigo	CO	0.51	0.50	13	0.302	0.765	83	570	16.03	13.51	11,440	2.16	44.3	880	4	1	0	
Lenno	CO	0.33	0.67	13	0.318	0.823	190	209	19.84	28.67	13,104	2.28	45.2	1,850	5	0	0	17.25
Lezzeno	CO	0.43	0.57	9	0.202	0.748	91	202	16.97	21.88	11,734	2.39	45.1	1,350	1	1	0	6.04
Limido	CO	0.59	0.41	14	0.285	0.770	869	276	7.28	25.77	15,140	2.53	38.0	1,200	4	1	0	
Lipomo	CO	0.55	0.45	20	0.178	0.782	2,368	384	3.16	35.9	14,942	2.41	43.8	1,250	2	1	0	
Livo	CO	0.11	0.89	8	0.182	0.738	6	675	43.95	9.55	10,184	1.95	49.5	710	4	1	0	-
Locate V	CO	0.65	0.35	14	0.212	0.802	732	274	4.14	28.46	13,967	2.41	42.7	1,175	1	1	0	-
Lomazzo	CO	0.64	0.37	16	0.184	0.787	998	296	11.65	29.91	15,437	2.33	42.6	1,450	3	0	0	
Longone	CO	0.49	0.51	13	0.147	0.815	1,178	368	12.71	33.45	15,840	2.46	42.7	1,250	4	1	0	-
Luisago	CO	0.63	0.37	15	0.195	0.765	1,265	327	15.47	26.74	14,504	2.34	42.4	1,300	4	1	0	
Lurago d'Erba	CO	0.63	0.37	16	0.225	0.797	1,159	351	12.13	30.5	15,110	2.40	42.5	1,175	3	1	0	-
Lurago Marinone	CO	0.41	0.59	15	0.213	0.798	669	294	8.21	27.52	14,838	2.45	41.4	1,125	4	0	0	
Lurate Caccivio	CO	0.59	0.41	15	0.186	0.762	1,668	322	14.25	25.65	12,563	2.42	43.2	1,275	2	0	1	
Magreglio	CO	0.42	0.59	12	0.297	0.740	204	744	18.34	30.77	13,167	2.00	43.3	880	4	1	0	
Mariano Com	CO	0.59	0.41	18	0.220	0.790	1,725	252	14.92	29.7	13,607	2.46	42.1	2,050	2	1	0	0.28
Maslianico	CO	0.70	0.30	17	0.276	0.773	2,531	225	4.88	27.69	11,686	2.24	44.7	1,575	5	1	0	
Menaggio	CO	0.33	0.67	10	0.182	0.777	242	203	26.59	32.59	13,705	2.30	46.3	1,400	4	1	0	28.34
Merone	CO	0.63	0.37	16	0.195	0.764	1,285	284	12.38	25.29	13,113	2.60	40.6	1,125	5	1	0	
Mezzegra	CO	0.36	0.64	13	0.438	0.821	302	206	21.17	26.52	11,772	2.27	44.2	1,750	4	0	0	14.50
Moltrasio	CO	0.61	0.39	12	0.270	0.769	183	247	5.63	37.2	20,078	2.05	48.3	2,000	4	0	0	30.75
Monguzzo	CO	0.63	0.37	16	0.214	0.785	620	320	11.53	29.46	14,833	2.62	40.2	1,125	5	1	0	
Montano Lucino	CO	0.50	0.50	16	0.203	0.773	937	331	4.54	30.53	13,878	2.36	42.5	1,300	4	1	0	16.07
Montemezzo	CO	0.24	0.76	10	0.204	0.709	28	522	46.50	16.31	9,596	2.02	45.3	710	4		0	
Montorfano	CO	0.54	0.46	21	0.138	0.782	745	414	5.08	36.95	16,934	2.39	44.0	1,425	3	1	0	
Mozzate	CO	0.38	0.62	15	0.164	0.788	805	255	-	31.6	13,966	2.34	41.6	1,300	1	1	0	
Musso	CO	0.22	0.78	10	0.191	0.760	249	201	36.50	17.86	10,941	2.26	46.7	1,000	4	1	0	

Nesso	CO	0.47	0.53	13	0.186	0.758	83	300	12.60	23.87	12,547	2.14	46.7	1,400	5	1	0	
Novedrate	CO	0.66	0.34	16	0.264	0.797	1,032	277	18.12	22.8	12,845	2.61	42.4	1,325	4		0	
Olgiate C	CO	0.58	0.42	19	0.208	0.749	1,047	415	14.48	27.82	12,525	2.37	43.4	1,375	5	0	1	0.20
Oltrona	CO	0.44	0.56	9	0.245	0.776	846	370	10.39	26.81	13,984	2.41	41.5	1,225	4	1	0	
Orsenigo	CO	0.61	0.39	20	0.194	0.801	616	390	8.17	28.23	15,296	2.46	41.7	1,175	4	1	1	
Ossuccio	CO	0.32	0.68	13	0.400	0.754	122	235	19.14	26.29	13,415	2.06	45.2	1,700	4	1	0	
Parè	CO	0.50	0.50	13	0.178	0.813	838	412	18.48	29.74	13,104	2.41	42.2	2,100	4		0	
Peglio	CO	0.12	0.89	7	0.179	0.762	16	650	42.11	11.73	9,322	1.86	47.9	710	4	1	0	
Pellio Intrelvi	CO	0.27	0.73	9	0.234	0.729	100	750	19.03	22.01	9,616	2.17	41.3	1,025	4	0	0	
Pianello del Lario	CO	0.38	0.62	13	0.307	0.803	104	213	35.70	23.09	10,892	2.20	47.4	1,000	4	1	0	9.13
Plesio	CO	0.23	0.77	10	0.179	0.715	49	595	28.60	19.82	11,336	2.12	46.9	1,000	4	1	0	6.25
Pognana	CO	0.43	0.57	13	0.163	0.691	150	307	9.38	18.97	12,326	2.14	46.4	1,350	4		0	
Ponna	CO	0.29	0.72	8	0.368	0.665	44	870	20.02	14.1	7,502	2.09	50.1	800	4	1	0	-
Ponte Lambro	CO	0.61	0.39	12	0.276	0.774	1,284	305	10.86	25.3	12,963	2.26	42.8	1,200	3	1	0	-
Porlezza	CO	0.21	0.79	11	0.214	0.720	253	275	25.63	20.56	11,973	2.31	41.9	900	4	1	0	56.18
Proserpio	CO	0.57	0.43	11	0.167	0.813	383	456	12.42	36.61	15,635	2.39	43.9	1,125	4	0	0	-
Pusiano	CO	0.60	0.40	11	0.180	0.796	413	264	15.08	28.56	15,580	2.34	43.1	1,300	4	1	0	
Ramponio Verna	CO	0.10	0.90	8	0.209	0.823	88	667	20.88	15.59	9,869	2.13	46.4	800	4	0	0	
Rezzago	CO	0.39	0.61	14	0.283	0.758	80	654	14.06	23.21	12,567	2.04	45.6	880	4	1	0	
Rodero	CO	0.42	0.58	11	0.218	0.745	501	394	13.46	20.36	7,984	2.45	41.0	1,125	4		0	-
Ronago	CO	0.54	0.46	15	0.198	0.732	830	357	19.81	22.27	8,023	2.56	40.7	1,200	4	1	0	-
Rovellasca	CO	0.62	0.38	15	0.192	0.792	2,226	244	16.40	29.78	14,532	2.37	42.3	1,875	3	1	0	-
Rovello	CO	0.72	0.28	16	0.162	0.755	1,085	240	17.59	27.95	13,731	2.34	42.6	1,275	1	0	0	
Sala Comacina	CO	0.37	0.63	13	0.238	0.694	114	213	18.22	21.22	10,472	2.60	54.6	1,700	4	1	0	
San Bartolomè	CO	0.11	0.89	10	0.208	0.619	94	852	30.79	13.8	3,588	2.42	44.8	800	4		0	
San Fedele Intelvi	CO	0.52	0.48	10	0.198	0.725	161	779	17.55	26.68	10,016	2.19	42.2	1,100	4	1	0	5.34
San Nazzaro	CO	0.15	0.86	7	0.227	0.696	25	995	31.26	7.58	5,089	2.11	47.6	800	1	0	0	-
San Siro	CO	0.26	0.75	11	0.237	0.749	94	216	30.44	16.46	9,649	2.07	47.7	1,100	4	1	0	4.79
Schignano	CO	0.30	0.71	9	0.325	0.709	85	600	13.39	19.97	9,276	2.07	46.2	1,025	4	0	0	
Senna C	CO	0.56	0.44	15	0.358	0.828	1,158	296	5.50	30.79	13,198	2.60	39.8	1,250	4	0	0	
Solbiate	CO	0.60	0.40	18	0.195	0.767	614	445	12.16	23.15	11,648	2.51	42.8	1,175	4	1	0	-
Sorico	CO	0.30	0.70	12	0.253	0.762	54	201	46.38	17.27	9,825	2.29	42.8	1,075	4		0	59.47
Sormano	CO	0.35	0.65	13	0.191	0.752	58	775	14.58	23.06	11,382	1.89	45.6	880	4		0	4.64
Stazzona	CO	0.25	0.75	10	0.338	0.785	84	515	39.33	12.43	9,457	2.21	46.0	710	4		0	
Tavernerio	CO	0.59	0.42	21	0.188	0.755	480	460	4.24	32.58	14,352	2.45	43.3	1,300	2	0	1	
Torno	CO	0.37	0.63	12	0.180	0.800	153	225	5.46	35.3	18,037	2.33	46.6	1,800	5	1	0	6.39
Tremezzo	CO	0.30	0.70	10	0.243	0.771	149	225	21.81	23.95	13,159	2.14	47.0	1,975	5	1	0	90.00
Trezzone	CO	0.27	0.73	10	0.186	0.806	59	430	45.13	19.88	10,127	2.36	42.6	710	4	1	0	
Turate	CO	0.42	0.58	14	0.228	0.790	904	240	4.19	29.27	14,969	2.44	41.9	1,350	2	1	0	
Uggiate-Trevano	CO	0.54	0.46	15	0.198	0.756	784	414	18.28	24.16	10,103	2.47	42.4	1,275	5	0	0	
Val Rezzo	CO	0.11	0.89	5	0.274	0.706	28	1044	29.28	20.98	2,077	2.59	41.8	800	3	1	0	-
Valbrona	CO	0.54	0.46	10	0.256	0.744	190	494	17.99	24.01	12,606	2.24	43.5	880	4	0	0	
Valmorea	CO	0.57	0.43	14	0.175	0.735	842	408	12.16	5.92	9,896	2.48	42.8	1,275	4	1	1	
Valsolda	CO	0.30	0.70	11	0.230	0.685	50	275	24.05	24.31	5,035	2.21	45.6	1,050	4		0	
Veleso	CO	0.31	0.69	13	0.181	0.602	45	826	13.19	14.57	11,516	1.87	47.2	880	4	0	0	
Veniano	CO	0.43	0.57	15	0.203	0.811	914	316	9.64	20.44	12,576	2.41	40.5	1,275	4	1	0	-
Vercana	CO	0.24	0.76	11	0.193	0.828	53	345	43.33	17.34	10,258	2.37	44.3	710	4	1	0	16.05
Vertemate Minoprio	CO	0.68	0.32	15	0.243	0.805	701	342	15.48	23.95	14,040	2.44	43.0	1,375	4	1	0	-
Villa Guardia	CO	0.63	0.37	16	0.202	0.773	1,024	350	12.81	29.98	14,108	2.40	42.5	1,350	5	1	1	0.11
Zelbio	CO	0.29	0.71	13	0.223	0.677	44	802	12.76	28.74	12,468	1.99	44.5	880	4	1	0	3.35
Acquanegra	CR	0.72	0.28	15	0.262	0.804	137	45	11.40	20.27	12,155	2.37	45.9	785	4	1	0	-
Agnadello	CR	0.72	0.28	16	0.265	0.799	318	94	50.32	21.66	12,393	2.54	39.8	1,025	2	0	0	
Annicco	CR	0.70	0.30	14	0.237	0.804	110	60	16.75	20.48	12,355	2.41	45.4	685	4	0	0	-
Azzanello	CR	0.68	0.32	12	0.283	0.765	63	68	21.48	19.76	12,315	2.32	45.0	710	2	0	0	-
Bagnolo CR	CR	0.76	0.25	16	0.198	0.825	465	82	41.00	22.54	12,686	2.53	43.1	980	4	0	0	-
Bonemerse	CR	0.57	0.43	18	0.216	0.857	255	40	4.62	30.89	15,233	2.50	42.6	800	4	1	0	-

Bordolano	CR	0.62	0.38	12	0.282	0.854	78	64	17.65	20.45	12,655	2.57	44.7	685	4	1	0	
Calvatone	CR	0.57	0.43	16	0.196	0.844	94	29	32.41	18.75	10,278	2.45	44.9	665	3	1	0	
Camisano	CR	0.71	0.29	15	0.248	0.813	120	96	40.67	23.26	12,357	2.60	42.8	840	2	0	0	-
Campagnola CR	CR	0.74	0.27	16	0.272	0.854	149	84	40.47	27.98	13,559	2.81	41.1	695	4		0	-
Capergnanica	CR	0.71	0.29	15	0.229	0.829	314	79	37.53	25.02	15,195	2.37	42.7	840	1	1	0	
Cappella Cantone	CR	0.59	0.41	11	0.283	0.815	44	60	19.29	20.48	12,692	2.57	44.0	690	4	1	0	-
Capralba	CR	0.71	0.29	16	0.221	0.820	180	96	45.59	21.42	12,308	2.43	42.9	680	5	1	0	-
Casalbuttano	CR	0.60	0.40	17	0.266	0.787	175	60	13.89	22.96	12,326	2.48	47.9	740	3	0	0	0.20
Casale CR	CR	0.73	0.27	15	0.304	0.781	211	92	41.06	22.37	12,873	2.64	40.1	840	4	1	0	
Casaletto Ceredano	CR	0.70	0.31	16	0.283	0.829	186	65	37.99	23.56	12,718	2.42	43.4	750	4		0	-
Casaletto di Sopra	CR	0.73	0.27	14	0.262	0.806	64	89	36.87	17.86	10,356	2.72	40.8	750	4	1	0	-
Casaletto Vaprio	CR	0.69	0.31	14	0.242	0.779	326	87	43.49	21.01	11,735	2.52	39.5	855	4	0	0	-
Casalmaggiore	CR	0.66	0.35	17	0.250	0.786	240	26	34.52	31.93	13,215	2.44	43.4	975	5	1	1	0.87
Casalmorano	CR	0.53	0.47	17	0.237	0.773	138	67	19.47	26.11	12,884	2.40	46.8	598	4	1	0	-
Castel Gabbiano	CR	0.60	0.40	15	0.302	0.798	84	100	44.26	27.9	11,553	2.62	46.5	615	4	0	0	-
Casteldidone	CR	0.62	0.38	8	0.205	0.746	55	27	30.58	26.2	12,433	2.42	40.2	593	4	1	0	-
Castelleone	CR	0.68	0.32	15	0.234	0.814	212	66	27.24	28.1	13,990	2.38	43.9	1,025	3	0	1	4.62
Castelverde	CR	0.63	0.37	17	0.257	0.820	187	52	6.37	31.46	14,538	2.46	43.0	880	5	1	0	
Castelvisconti	CR	0.63	0.37	11	0.240	0.849	34	66	19.98	21.33	9,833	2.47	45.1	593	4	0	0	-
Cella Dati	CR	0.61	0.39	11	0.359	0.843	29	34	15.86	27.47	13,284	2.25	47.8	603	4	1	0	-
Chieve	CR	0.70	0.30	15	0.304	0.796	355	77	39.44	20.85	13,099	2.47	41.1	610	4	1	0	
Cicognolo	CR	0.58	0.42	16	0.186	0.879	138	44	13.44	22.6	12,043	2.48	43.5	603	4	1	0	
Cingia de' Botti	CR	0.54	0.46	11	0.233	0.745	91	31	20.24	19.43	10,137	2.77	49.8	730	4	0	0	
Corte Cortesi	CR	0.64	0.36	13	0.228	0.817	89	60	15.31	19.25	10,568	2.58	42.4	735	4	1	0	
Corte Frati	CR	0.63	0.37	16	0.288	0.810	70	51	10.82	20.93	13,181	2.38	44.7	603	4	1	0	
Credera	CR	0.73	0.27	14	0.222	0.853	114	70	34.56	21.18	12,619	2.53	44.5	600	4	1	0	-
Crema	CR	0.68	0.33	17	0.242	0.810	969	79	37.48	37.21	16,845	2.15	45.7	1,375	3	0	0	0.86
Cremona	CR	0.45	0.55	19	0.275	0.808	1,025	45	-	40.3	16,569	2.12	46.4	1,375	2	0	0	1.66
Cremosano	CR	0.69	0.31	15	0.236	0.816	283	83	41.92	21.64	13,605	2.40	40.3	695	5	1	0	-
Crotta d'Adda	CR	0.63	0.37	11	0.230	0.787	51	52	13.69	19.97	12,306	2.25	44.5	593	4		0	-
Cumignano	CR	0.65	0.35	14	0.283	0.794	68	77	28.74	22.02	10,064	2.48	43.1	598	4	1	0	-
Derovere	CR	0.52	0.48	10	0.262	0.805	31	36	17.51	24.59	13,188	2.20	48.6	603	4	1	0	-
Dovera	CR	0.70	0.30	14	0.273	0.800	189	76	45.83	23.85	12,400	2.47	42.4	845	4	0	0	
Drizzona	CR	0.57	0.43	8	0.336	0.807	46	34	25.26	23.44	11,973	2.42	45.5	720	5	1	0	
Fiesco	CR	0.72	0.28	14	0.257	0.781	149	74	29.72	19.63	12,195	2.56	39.9	750	4		0	-
Formigara	CR	0.70	0.31	12	0.253	0.809	87	59	22.38	18.02	11,664	2.44	46.7	608	4	0	0	
Gabbioneta-Binanuova	CR	0.62	0.39	18	0.245	0.841	57	38	17.48	22.53	12,701	2.31	47.1	573	4	1	0	
Gadesco-Pieve	CR	0.65	0.35	16	0.282	0.822	119	44	7.28	27.59	12,862	2.36	41.1	603	4	1	0	
Genivolta	CR	0.69	0.31	14	0.268	0.814	63	70	24.83	20.41	11,479	2.50	44.3	740	5	1	0	-
Gerre	CR	0.64	0.36	13	0.344	0.853	159	37	3.29	28.38	14,925	2.29	40.7	603	2	0	0	-
Gombito	CR	0.70	0.30	15	0.289	0.802	70	65	27.32	20.36	12,272	2.30	45.0	608	4	1	0	-
Grontardo	CR	0.68	0.32	16	0.271	0.852	122	46	12.09	22.51	12,432	2.52	44.0	603	4	1	0	-
Grumello	CR	0.73	0.28	16	0.271	0.814	83	50	14.21	21.08	12,800	2.36	45.6	603	4	1	0	
Gussola	CR	0.74	0.26	14	0.228	0.809	112	28	28.48	22.43	11,220	2.44	44.5	593	1	1	0	
Isola Dovarese	CR	0.69	0.32	17	0.278	0.815	130	35	22.59	21.26	12,710	2.35	48.3	603	4	0	0	
Izano	CR	0.70	0.30	15	0.304	0.821	330	77	32.72	23.25	12,799	2.43	42.3	615	4		0	-
Madignano	CR	0.69	0.31	15	0.264	0.838	271	72	33.34	27.81	14,079	2.56	42.6	845	4	0	0	-
Malagnino	CR	0.67	0.34	13	0.264	0.865	148	43	6.80	34.76	15,763	2.41	40.6	620	4	1	0	-
Martignana Po	CR	0.80	0.20	15	0.314	0.778	136	26	30.91	21.1	11,638	2.51	40.3	593	5	0	0	-
Monte CR	CR	0.69	0.31	15	0.278	0.807	1,008	84	44.51	23.25	12,591	2.59	41.1	840	5	1	0	
Montodine	CR	0.67	0.33	15	0.265	0.856	219	67	30.09	22.22	12,504	2.49	42.3	615	5	1	0	-
Moscazzano	CR	0.67	0.33	16	0.276	0.811	103	68	32.08	21.66	11,762	2.54	44.3	840	5	1	0	
Motta Baluffi	CR	0.75	0.25	14	0.228	0.806	59	31	20.05	20.39	11,137	2.49	46.5	603	5	1	0	
Offanengo	CR	0.67	0.33	15	0.272	0.850	471	83	35.04	24.64	13,073	2.52	42.8	1,050	4	1	0	-
Olmeneta	CR	0.65	0.35	15	0.265	0.832	106	55	11.10	25.45	12,331	2.40	44.1	603	5	1	0	-
Ostiano	CR	0.63	0.37	15	0.247	0.789	155	43	19.94	18.4	11,087	2.49	45.6	730	2	0	0	

Paderno Ponchielli	CR	0.55	0.45	14	0.257	0.818	61	58	13.75	21.14	11,876	2.33	46.7	598	4		0	
Palazzo Pignano	CR	0.68	0.32	14	0.267	0.807	437	87	44.51	21.51	12,465	2.42	42.4	840	3	0	0	-
Pandino	CR	0.65	0.35	14	0.335	0.811	401	85	47.80	25.69	13,048	2.44	42.6	1,105	5	1	0	-
Persico Dosimo	CR	0.60	0.40	16	0.291	0.853	169	48	8.18	30.59	13,879	2.43	41.5	670	5	1	0	
Pescarolo	CR	0.60	0.41	17	0.295	0.814	97	45	13.98	23.36	12,011	2.45	43.6	603	4	1	0	
Pessina CR	CR	0.58	0.43	13	0.300	0.844	30	42	18.14	18.69	10,672	2.52	45.2	578	4	1	0	
Piadena	CR	0.66	0.35	14	0.251	0.795	183	34	26.71	25.74	12,569	2.39	45.5	720	4	0	1	
Pianengo	CR	0.73	0.27	16	0.245	0.851	443	83	39.44	27	12,438	2.47	41.6	700	5	1	0	
Pieve d'Olmi	CR	0.63	0.38	14	0.234	0.818	68	36	9.12	25.41	12,579	2.49	43.8	603	4	1	0	-
Pieve San Giacomo	CR	0.50	0.50	15	0.232	0.826	107	39	12.42	25.63	11,914	2.44	44.1	670	4		0	-
Pizzighettone	CR	0.66	0.35	15	0.223	0.799	209	46	19.58	25.57	13,767	2.34	45.9	670	2	0	1	0.46
Pozzaglio	CR	0.66	0.34	13	0.345	0.823	72	50	7.32	23.26	11,868	2.55	42.2	670	4	0	0	-
Quintano	CR	0.67	0.33	15	0.247	0.811	330	93	45.02	20.82	11,811	2.64	40.1	615	4	1	0	-
Ricengo	CR	0.69	0.31	15	0.298	0.812	140	86	38.26	25.57	11,621	2.77	37.4	615	5	1	0	-
Ripalta Arpina	CR	0.76	0.24	14	0.260	0.826	154	72	29.80	19.32	12,299	2.49	42.7	685	5	1	0	
Ripalta CR	CR	0.71	0.29	17	0.199	0.851	291	78	34.14	26.45	14,477	2.37	44.3	685	3	1	0	
Ripalta Guerina	CR	0.76	0.24	15	0.219	0.870	179	73	31.63	22.62	12,867	2.65	41.2	685	3	1	0	
Rivarolo Re	CR	0.75	0.25	14	0.222	0.799	75	22	36.70	23.18	12,032	2.45	44.7	593	5	1	0	
Rivolta d'Adda	CR	0.70	0.30	15	0.131	0.795	266	101	54.87	25.14	13,466	2.36	44.8	1,250	5	0	0	0.05
Robecco	CR	0.59	0.41	15	0.325	0.798	134	48	14.23	19.1	10,880	2.60	45.5	665	3	1	0	-
Romanengo	CR	0.69	0.31	14	0.238	0.850	207	83	33.02	25.97	12,565	2.48	42.4	615	5	1	0	
Salvirola	CR	0.78	0.22	15	0.202	0.829	159	75	31.29	19.64	12,745	2.42	40.7	615	4	1	0	
San Bassano	CR	0.56	0.44	15	0.228	0.774	160	59	20.96	23.81	12,123	2.57	45.2	610	3	1	0	
San Daniele Po	CR	0.62	0.38	17	0.235	0.813	62	33	14.54	22.83	12,454	2.28	48.4	665	4	0	0	-
San Giovanni in Croce	CR	0.62	0.38	15	0.248	0.847	117	28	27.97	26.15	12,245	2.51	42.9	593	5	1	0	
San Martino Lago	CR	0.78	0.22	13	0.247	0.813	45	31	23.72	24.75	11,989	2.50	48.6	548	4	1	0	
Scandolara Ravara	CR	0.77	0.23	14	0.184	0.774	85	30	23.81	21.23	10,243	2.39	47.7	593	4	1	0	-
Scandolara Ripa d'Oglio	CR	0.62	0.38	11	0.319	0.763	104	47	13.99	22.16	11,493	2.37	46.0	603	4	0	0	-
Sergnano	CR	0.72	0.28	16	0.265	0.817	290	91	41.35	24.49	12,318	2.54	41.0	690	2	0	0	-
Sesto	CR	0.67	0.33	15	0.250	0.814	118	52	10.00	26.32	13,794	2.52	44.2	603	4	1	0	
Solarolo Rainero	CR	0.62	0.38	12	0.257	0.815	89	28	26.45	22.11	10,884	2.47	45.5	593	4	0	0	
Soncino	CR	0.68	0.32	14	0.264	0.832	171	86	31.85	24.25	13,322	2.39	44.7	700	2	1	0	0.55
Soresina	CR	0.58	0.43	15	0.221	0.796	316	70	21.40	29.69	13,368	2.21	45.0	940	3	1	1	0.36
Sospiro	CR	0.53	0.47	16	0.279	0.743	167	36	51.61	21.8	11,423	2.86	47.9	670	3	0	0	
Spinadesco	CR	0.68	0.32	17	0.258	0.850	91	48	8.12	24.68	13,081	2.40	43.7	603	4	1	0	-
Spineda	CR	0.57	0.43	12	0.225	0.810	60	23	39.12	17.43	11,092	2.28	47.1	548	4	1	0	-
Spino d'Adda	CR	0.74	0.26	15	0.223	0.799	348	84	51.09	24.97	13,534	2.45	41.7	1,175	3	0	0	1.53
Stagno Lombardo	CR	0.70	0.30	15	0.276	0.849	40	36	8.42	24.76	13,187	2.55	44.9	603	5	1	0	0.16
Ticengo	CR	0.71	0.29	14	0.209	0.886	56	76	30.27	22.83	12,028	2.45	44.2	608	3	0	0	-
Torlino Vimercati	CR	0.69	0.31	14	0.173	0.869	80	88	46.11	28.22	14,219	2.42	42.3	615	4	1	0	
Tornata	CR	0.51	0.50	7	0.229	0.874	49	29	31.80	22.48	9,826	2.55	44.4	593	5	1	0	-
Torre Picenardi	CR	0.73	0.27	14	0.241	0.809	104	37	20.32	24.54	12,311	2.36	45.9	603	5	1	0	
Torricella Pizzo	CR	0.77	0.23	13	0.297	0.804	27	29	24.77	18.65	10,160	2.36	48.6	558	5	1	0	
Trescore CR	CR	0.73	0.27	15	0.249	0.812	489	86	43.20	23.14	12,549	2.40	41.5	690	5	1	0	-
Trigolo	CR	0.65	0.36	14	0.244	0.760	108	70	27.25	23.07	12,558	2.41	45.8	608	4	0	0	-
Vaiano CR	CR	0.69	0.31	16	0.305	0.811	610	82	43.34	21.39	12,606	2.50	43.3	815	2	0	0	-
Vailate	CR	0.70	0.30	14	0.278	0.773	460	103	49.28	22.72	12,564	2.41	41.8	1,050	2	0	0	
Vescovato	CR	0.48	0.52	17	0.183	0.803	232	46	11.56	23.84	12,028	2.58	43.7	730	3	1	0	
Volongo	CR	0.61	0.39	10	0.332	0.807	70	43	23.00	19.24	11,076	2.41	46.7	573	4	0	0	-
Voltido	CR	0.73	0.27	12	0.224	0.782	33	35	24.08	13.44	10,314	2.33	48.3	555	4	1	0	-
Abbadia Lariana	LC	0.61	0.40	15	0.176	0.800	189	204	7.31	31.96	15,574	2.21	43.9	1,400	5	1	0	5.72
Airuno	LC	0.73	0.28	16	0.178	0.807	694	222	11.46	25.14	12,909	2.51	42.2	1,125	5		0	
Annone Brianza	LC	0.57	0.43	15	0.154	0.841	394	265	8.15	25.52	13,719	2.55	41.9	1,100	5	1	0	
Ballabio	LC	0.60	0.40	14	0.237	0.796	274	661	4.99	30.82	14,523	2.39	39.6	1,675	4	1	0	1.68
Barzago	LC	0.68	0.32	16	0.195	0.803	701	358	13.07	22.92	14,283	2.55	42.5	1,025	5	1	0	
Barzanò	LC	0.64	0.36	16	0.204	0.804	1,448	370	15.06	31.27	16,096	2.48	43.4	1,150	5	0	0	2.44

Barzio	LC	0.46	0.54	13	0.234	0.762	62	769	10.94	30.51	15,101	2.05	46.2	1,675	4		0	5.10
Bellano	LC	0.63	0.37	15	0.234	0.768	286	202	22.18	27.59	15,330	2.01	46.8	1,600	4	0	0	3.16
Bosisio parini	LC	0.58	0.42	15	0.222	0.802	532	270	10.52	29	14,756	2.44	41.6	1,125	3	1	0	1.77
Brivio	LC	0.64	0.36	16	0.247	0.797	597	208	13.07	26.13	14,510	2.47	42.4	1,175	5	1	0	
Bulciago	LC	0.69	0.31	16	0.222	0.829	954	305	14.81	23.25	12,940	2.63	41.3	1,150	3	1	0	
Calco	LC	0.61	0.39	15	0.152	0.785	1,121	283	14.63	34.77	16,377	2.29	41.2	1,150	5	1	0	0.05
Calolziocorte	LC	0.59	0.41	16	0.289	0.775	1,551	241	7.24	25.3	13,638	2.41	44.0	1,450	1	1	0	0.23
Carenno	LC	0.64	0.36	16	0.204	0.785	190	635	7.40	23.58	11,098	2.38	42.9	1,125	1	0	0	
Casargo	LC	0.37	0.63	14	0.221	0.733	41	804	20.12	20.21	11,759	2.00	46.7	1,155	5	1	0	1.70
Casatenovo	LC	0.65	0.36	17	0.214	0.822	1,009	340	19.09	33.47	16,049	2.43	43.5	1,100	5	1	0	
Cassago Brianza	LC	0.66	0.34	15	0.216	0.807	1,248	334	15.58	25.49	13,798	2.53	42.2	1,100	5	1	0	
Cassina Valsassina	LC	0.44	0.56	12	0.438	0.742	184	849	10.30	17.8	14,493	1.94	46.0	1,400	4	1	0	-
Castello Brianza	LC	0.64	0.36	15	0.221	0.818	694	350	11.64	24.91	14,936	2.56	40.5	1,025	3	1	0	
Cernusco L	LC	0.64	0.36	16	0.191	0.791	1,024	267	18.32	37.33	16,928	2.30	43.9	1,325	5	0	0	
Cesana Brianza	LC	0.61	0.39	12	0.221	0.833	696	300	9.10	20.9	15,194	2.52	42.6	1,125	5		0	-
Civate	LC	0.41	0.59	15	0.200	0.812	442	269	5.56	26.34	14,598	2.48	43.8	1,125	5		0	1.21
Colico	LC	0.59	0.41	15	0.186	0.759	214	218	30.87	28.95	14,787	2.24	43.3	1,550	5		0	7.94
Colle Brianza	LC	0.63	0.37	16	0.227	0.763	205	558	10.80	28.05	14,489	2.40	41.5	1,025	5	1	0	-
Cortenova	LC	0.38	0.62	14	0.199	0.744	107	483	16.12	21.22	15,259	2.34	44.2	1,160	3	1	0	
Costa Masnaga	LC	0.62	0.38	16	0.228	0.786	845	318	13.85	23.95	13,931	2.48	42.6	1,125	5	0	0	
Crandola Valsassina	LC	0.48	0.52	12	0.284	0.765	30	780	18.75	12.04	11,612	2.05	45.0	1,200	3	0	0	
Cremella	LC	0.68	0.32	16	0.209	0.818	954	383	15.23	26.77	14,485	2.53	41.6	1,100	5	1	0	2.91
Cremeno	LC	0.43	0.57	12	0.285	0.763	111	792	10.24	26.35	14,793	2.15	41.8	1,525	3	0	0	
Dervio	LC	0.66	0.34	15	0.143	0.778	231	238	25.64	30.97	14,388	2.03	46.8	1,400	5	1	0	21.00
Dolzago	LC	0.68	0.32	16	0.309	0.812	1,057	298	11.02	22.91	14,831	2.48	41.8	1,050	4	0	0	
Dorio	LC	0.78	0.22	11	0.175	0.755	26	210	28.08	21.68	13,383	2.08	47.6	1,200	4	1	0	
Ello	LC	0.71	0.29	16	0.182	0.786	517	411	8.31	31.86	16,579	2.67	42.9	1,025	5	1	0	-
Erve	LC	0.67	0.34	13	0.383	0.703	119	559	5.43	19.05	11,439	2.34	43.9	1,020	5	1	0	-
Esino Lario	LC	0.43	0.57	12	0.291	0.740	40	910	16.42	29.31	13,455	1.98	45.9	1,150	4	1	0	2.17
Galbiate	LC	0.69	0.31	16	0.163	0.796	532	371	4.79	31.09	15,406	2.45	43.8	1,140	5	1	0	0.09
Garbagnate	LC	0.62	0.38	16	0.210	0.852	710	299	12.05	19.13	14,605	2.55	41.1	1,100	4	1	0	
Garlate	LC	0.61	0.39	16	0.162	0.810	1,245	205	4.86	27.51	14,122	2.37	43.2	1,275	5	0	0	4.25
Imbersago	LC	0.60	0.40	17	0.161	0.803	785	249	16.95	37.36	17,558	2.46	42.9	1,275	5	1	0	-
Introbio	LC	0.50	0.50	15	0.195	0.768	78	586	13.65	28.08	13,224	2.29	42.6	1,250	5	0	0	1.24
Introzzo	LC	0.28	0.72	10	0.283	0.721	34	704	25.53	25	9,820	1.93	49.4	1,150	3	1	0	
Lecco	LC	0.56	0.44	15	0.285	0.791	1,029	214	-	36.81	17,276	2.19	45.4	1,775	6	0	0	1.51
Lierna	LC	0.77	0.23	16	0.151	0.783	191	202	13.78	30.79	14,619	2.18	43.1	1,550	2	0	0	1.03
Lomagna	LC	0.69	0.31	17	0.270	0.818	1,264	255	20.95	31.67	17,516	2.40	41.3	1,225	5	1	0	
Malgrate	LC	0.59	0.41	16	0.186	0.826	2,117	231	2.19	38.66	16,243	2.31	44.6	1,275	4	1	0	6.14
Mandello Lario	LC	0.49	0.51	15	0.210	0.786	254	214	9.59	31.91	15,274	2.34	45.8	1,650	5	1	0	1.54
Margno	LC	0.40	0.60	14	0.230	0.826	101	730	19.56	24.41	12,312	2.08	43.0	1,225	3	0	0	
Merate	LC	0.59	0.41	16	0.241	0.806	1,337	292	17.46	39.16	17,598	2.38	45.1	1,600	2	0	0	0.79
Missaglia	LC	0.54	0.46	16	0.191	0.801	761	326	17.12	30.08	15,654	2.36	42.6	1,425	2	1	0	
Moggio	LC	0.41	0.59	12	0.335	0.796	36	890	10.71	25.6	14,856	1.96	46.9	1,575	3	1	0	
Molteno	LC	0.60	0.40	16	0.173	0.800	1,134	292	11.20	21.73	13,962	2.62	41.6	1,125	4	1	0	
Monte Marenzo	LC	0.70	0.30	16	0.191	0.804	653	440	10.24	22.71	13,157	2.69	40.2	1,090	5	1	0	-
Montevecchia	LC	0.71	0.29	17	0.235	0.810	423	479	16.77	40.36	19,506	2.33	42.9	1,325	5	1	0	0.98
Monticello B	LC	0.73	0.27	19	0.228	0.787	908	406	17.60	28.87	15,011	2.43	45.3	1,125	3	1	0	
Morterone	LC	0.18	0.82	3	0.314	0.719	3	1070	6.52	7.41	17,519	1.42	50.9	925	3	1	0	
Nibionno	LC	0.63	0.37	17	0.273	0.780	1,025	306	15.27	20.99	12,537	2.57	41.6	1,125	2	0	0	
Oggiono	LC	0.55	0.45	16	0.197	0.790	1,122	268	8.30	29.78	15,706	2.40	43.2	1,225	2	0	0	0.96
Olgiate Molgora	LC	0.66	0.34	16	0.134	0.786	864	287	13.96	30.89	14,773	2.41	42.8	1,150	5	1	0	0.06
Olginate	LC	0.64	0.37	16	0.237	0.796	897	206	7.08	24.2	14,128	2.46	43.1	1,150	5	1	1	
Oliveto Lario	LC	0.49	0.52	11	0.287	0.786	73	208	12.47	29.36	14,252	1.96	46.3	1,150	5	1	0	4.43
Osnago	LC	0.69	0.31	16	0.216	0.809	1,098	249	20.04	34.8	15,795	2.34	42.7	1,325	5	1	1	
Paderno d'Adda	LC	0.68	0.32	17	0.208	0.812	1,089	266	19.82	31.66	15,289	2.41	41.6	1,275	5	1	0	

Pagnona	LC	0.43	0.57	10	0.225	0.691	44	790	22.70	9.57	9,506	2.37	48.3	1,000	4	1	0	-
Parlasco	LC	0.34	0.66	12	0.143	0.825	48	679	18.56	12.71	13,194	1.99	46.5	1,025	3	1	0	-
Pasturo	LC	0.55	0.45	15	0.222	0.782	89	641	11.15	22.13	12,157	2.44	41.3	1,165	5	0	0	0.39
Perego	LC	0.63	0.38	16	0.261	0.769	419	374	13.49	26.8	14,716	2.57	41.5	1,200	5	1	0	
Perledo	LC	0.51	0.49	15	0.235	0.670	80	395	19.77	23.48	13,784	1.99	51.2	1,250	4	1	0	12.45
Pescate	LC	0.71	0.29	16	0.174	0.831	1,034	214	2.57	30.99	16,185	2.44	42.0	1,300	3	1	1	
Premana	LC	0.48	0.52	12	0.213	0.799	67	1000	21.88	14.77	11,205	2.76	41.3	1,075	3	0	0	
Primaluna	LC	0.44	0.57	14	0.201	0.779	96	558	14.49	17.52	12,637	2.47	40.7	1,125	3		0	
Robbiate	LC	0.72	0.28	18	0.220	0.800	1,320	265	18.47	34.23	15,890	2.39	41.7	1,250	5	1	0	
Rogeno	LC	0.68	0.33	16	0.236	0.807	659	292	12.89	25.76	13,683	2.54	41.1	1,065	3	0	0	-
Rovagnate	LC	0.62	0.39	16	0.229	0.792	639	342	13.26	28.76	14,166	2.52	41.3	1,200	5	1	0	-
Santa Maria Hoè	LC	0.61	0.39	16	0.266	0.804	780	371	12.61	29.39	15,650	2.55	41.3	1,080	4		0	-
Sirone	LC	0.67	0.33	16	0.207	0.823	742	273	11.16	22.14	13,782	2.55	41.2	1,015	3	1	0	
Sirtori	LC	0.69	0.31	16	0.161	0.769	677	457	14.38	33.27	17,261	2.51	42.7	1,000	5	1	0	-
Sueglio	LC	0.29	0.71	10	0.211	0.647	36	775	26.16	15.75	12,380	1.90	52.3	975	4	0	0	
Suello	LC	0.60	0.41	14	0.175	0.828	662	275	8.30	21.32	14,464	2.56	42.1	945	3	0	0	
Taceno	LC	0.36	0.64	13	0.212	0.776	149	507	19.02	23.94	12,856	2.25	42.0	1,175	3	1	0	
Torre de Busi	LC	0.61	0.39	14	0.152	0.711	219	472	10.84	15.8	12,551	2.44	40.5	1,100	3	0	0	
Tremenico	LC	0.35	0.65	10	0.299	0.706	20	754	24.69	13.76	11,829	1.81	56.7	1,000	3	1	0	
Valgreghentino	LC	0.63	0.37	16	0.163	0.822	545	304	8.53	24.22	14,706	2.55	41.9	1,040	5	1	0	-
Valmadrera	LC	0.64	0.37	17	0.189	0.822	936	234	3.62	27.4	14,085	2.53	42.9	1,150	5	1	0	0.47
Varenna	LC	0.29	0.71	11	0.234	0.783	70	220	19.58	32.97	17,726	1.85	48.9	1,750	4	1	0	49.72
Vendrogno	LC	0.36	0.64	13	0.370	0.669	27	731	20.69	17.25	10,253	1.65	50.4	1,075	4	1	0	
Vercurago	LC	0.59	0.41	12	0.224	0.804	1,341	225	5.26	28.62	14,606	2.34	45.4	1,225	5	1	0	0.92
Verderio Inf	LC	0.73	0.27	17	0.236	0.825	772	249	21.26	28.25	15,092	2.47	38.6	1,065	5	1	0	-
Verderio Sup	LC	0.68	0.32	15	0.195	0.817	1,018	250	21.11	36.53	16,303	2.48	41.6	1,065	5	1	0	-
Vestreno	LC	0.34	0.66	10	0.311	0.628	113	587	26.04	24.6	10,548	2.22	44.5	1,050	4	1	0	
Viganò	LC	0.71	0.29	16	0.228	0.796	1,250	390	15.76	25.99	15,807	2.39	43.3	1,000	5	1	0	-
Bertonico	LO	0.58	0.42	13	0.210	0.810	59	63	19.34	26.47	12,453	2.38	45.1	900	4	1	0	-
Boffalora	LO	0.69	0.31	9	0.305	0.769	210	78	3.31	24.85	12,880	2.37	39.8	995	3	0	0	
Borghetto LO	LO	0.56	0.44	13	0.250	0.784	187	68	13.68	21.91	13,094	2.44	43.4	900	5	1	0	
Borgo San Giovanni	LO	0.34	0.66	13	0.196	0.820	300	77	7.00	25.39	13,553	2.53	38.9	945	4	1	0	-
Brembio	LO	0.65	0.35	17	0.237	0.818	160	67	15.71	20.95	13,087	2.44	43.4	900	5	1	0	-
Camairago	LO	0.55	0.45	12	0.242	0.785	52	59	24.94	15.62	12,401	2.54	41.2	895	4	1	0	-
Casaletto Lo	LO	0.63	0.37	15	0.322	0.797	288	80	9.57	26.18	13,637	2.48	39.5	970	4	1	0	-
Casalmaiocco	LO	0.61	0.39	18	0.267	0.844	654	88	7.62	35.11	15,978	2.53	39.5	1,015	3	1	0	-
Casalpusterlengo	LO	0.62	0.38	16	0.267	0.809	585	60	22.62	29.82	14,409	2.37	43.3	1,175	3	0	0	
Caselle Landi	LO	0.61	0.39	15	0.236	0.791	64	44	36.45	21.29	12,846	2.33	46.7	815	4	0	0	
Caselle Lurani	LO	0.64	0.36	17	0.234	0.767	411	80	10.52	24.97	11,968	2.50	39.2	925	5	1	0	-
Castelnuovo Bocca d'Adda	LO	0.60	0.40	15	0.258	0.690	81	49	39.78	23.42	12,284	2.33	46.3	800	3	1	0	
Castiglione d'Adda	LO	0.62	0.38	15	0.210	0.783	364	60	21.94	23.48	12,664	2.38	44.0	920	5	0	0	-
Castiraga	LO	0.63	0.37	14	0.224	0.815	511	65	10.07	29.39	13,915	2.56	38.9	925	3	1	0	-
Cavacurta	LO	0.59	0.41	11	0.220	0.788	119	60	26.86	21.97	12,363	2.44	44.4	965	4		0	-
Cavenago d'Adda	LO	0.65	0.35	18	0.214	0.828	138	73	11.83	24.62	13,643	2.31	43.0	950	3	0	0	-
Cervignano d'Adda	LO	0.61	0.39	14	0.240	0.797	516	87	5.45	24.45	12,974	2.46	39.4	970	4	1	0	
Codogno	LO	0.62	0.38	16	0.276	0.767	740	57	26.61	36.3	15,617	2.26	44.9	1,500	5	0	1	
Comazzo	LO	0.65	0.35	16	0.317	0.799	174	98	11.68	20.14	13,450	2.41	38.5	1,150	4	0	0	-
Cornegliano Laudense	LO	0.69	0.31	12	0.228	0.832	511	78	5.87	34.02	16,486	2.44	41.3	1,015	5	1	0	
Corno Giovine	LO	0.63	0.37	15	0.210	0.804	120	50	32.04	32	13,245	2.24	45.0	810	3	1	0	-
Cornovecchio	LO	0.71	0.29	6	0.472	0.796	33	52	34.08	23.28	11,264	2.02	46.1	810	5	1	0	-
Crespiatica	LO	0.65	0.35	12	0.230	0.815	303	76	8.63	19.31	12,480	2.35	40.4	850	5	1	0	-
Fombio	LO	0.58	0.42	15	0.217	0.798	309	57	27.71	22.86	11,914	2.39	41.1	875	3	1	0	
Galgagnano	LO	0.63	0.37	8	0.284	0.798	205	86	3.06	29.76	13,872	2.44	38.0	900	4	1	0	-
Graffignana	LO	0.68	0.32	13	0.268	0.820	245	67	14.47	28.27	14,379	2.54	44.1	925	3	1	0	
Guardamiglio	LO	0.62	0.38	15	0.158	0.806	259	49	30.36	28.58	14,186	2.38	43.6	875	4	0	0	
Livraga	LO	0.66	0.34	15	0.203	0.784	216	67	17.09	22.17	13,120	2.36	44.5	900	5	1	0	

Lodi	LO	0.48	0.52	20	0.290	0.803	1,049	87	3.65	40.63	12,508	2.27	45.1	2,325	6	1	0	1.04
Lodi Vecchio	LO	0.65	0.35	16	0.259	0.805	467	82	5.47	23.92	17,301	2.36	42.4	1,225	5	1	0	
Maccastorna	LO	0.62	0.38	5	0.370	0.816	11	45	36.83	36.84	13,005	2.70	40.8	800	4	1	0	-
Mairago	LO	0.64	0.37	15	0.185	0.828	124	69	12.72	27.8	14,801	2.54	40.8	850	5	1	0	
Maleo	LO	0.62	0.38	15	0.274	0.762	163	58	29.63	26.19	13,543	2.42	46.3	850	3	1	0	
Marudo	LO	0.72	0.28	13	0.258	0.801	382	77	11.65	21.02	13,103	2.37	40.3	900	3	1	0	
Massalengo	LO	0.73	0.28	14	0.216	0.788	509	76	8.08	24.83	12,313	2.47	39.9	925	5	0	0	
Meleti	LO	0.63	0.37	7	0.354	0.789	65	40	37.62	22.48	13,180	2.40	49.5	825	3	1	0	-
Merlino	LO	0.64	0.36	17	0.250	0.817	165	101	11.26	28.19	12,793	2.42	37.9	925	3	1	0	-
Montanaso Lombrado	LO	0.52	0.48	16	0.160	0.854	237	83	-	33.91	13,097	2.41	42.2	1,040	3	1	0	-
Mulazzano	LO	0.68	0.32	16	0.210	0.813	365	91	6.87	24.88	16,667	2.44	40.7	1,425	4	0	1	-
Orio Litta	LO	0.60	0.40	14	0.231	0.804	205	63	20.71	24.29	11,963	2.46	43.9	825	4	0	0	
Ospedaletto Lo	LO	0.66	0.34	16	0.210	0.811	224	64	20.49	27.41	12,396	2.46	41.3	875	4	1	0	
Ossago LO	LO	0.57	0.44	12	0.253	0.845	122	71	20.49	25.25	13,165	2.49	42.1	900	5	1	1	
Pieve Fissiraga	LO	0.70	0.31	12	0.263	0.824	137	76	8.10	35.29	15,041	2.49	38.3	925	5	1	0	
Salerano sul Lambro	LO	0.68	0.32	15	0.223	0.824	626	77	7.87	20.51	12,893	2.51	41.4	970	4	1	0	-
San Fiorano	LO	0.62	0.38	15	0.228	0.836	201	56	29.79	29.8	15,659	2.43	43.5	850	5	1	0	-
San Martino in Strada	LO	0.63	0.37	15	0.245	0.833	276	73	8.15	32.92	14,849	2.36	43.5	1,125	5	1	0	
San Rocco al porto	LO	0.69	0.31	13	0.203	0.798	115	47	33.43	26.97	13,694	2.31	43.7	1,000	5	1	0	-
Sant'Angelo LO	LO	0.52	0.48	14	0.249	0.801	641	73	11.84	29.04	12,557	2.39	42.5	1,125	4	1	0	
Santo Stefano LO	LO	0.64	0.36	15	0.280	0.810	185	48	31.91	22.81	13,661	2.30	45.1	800	3	1	0	
Secugnago	LO	0.69	0.31	13	0.245	0.822	297	68	15.09	25.41	13,068	2.31	42.7	850	4		0	-
Senna Lo	LO	0.63	0.37	13	0.202	0.778	75	62	22.70	21.05	11,737	2.49	44.9	800	5		0	-
Somaglia	LO	0.64	0.37	13	0.224	0.801	181	57	24.42	23.43	12,436	2.51	41.9	850	5	1	0	
Sordio	LO	0.65	0.35	13	0.253	0.812	1,134	85	8.24	27.85	14,261	2.36	40.0	1,450	3	0	0	
Tavazzano	LO	0.62	0.38	17	0.266	0.801	386	82	4.98	28.46	13,053	2.48	40.4	1,040	5	1	0	2.10
Terranova Passerini	LO	0.53	0.48	7	0.227	0.829	81	63	22.34	22.79	13,333	2.51	42.1	875	3	1	0	-
Turano LO	LO	0.63	0.37	16	0.190	0.785	96	68	15.41	22.51	12,826	2.34	43.0	875	5	1	0	
Valera Fratta	LO	0.65	0.35	14	0.272	0.802	205	78	13.56	23.49	11,884	2.58	39.6	900	2	1	0	
Villanova Sillaro	LO	0.61	0.39	8	0.253	0.804	131	69	10.92	22.54	11,062	2.65	38.1	925	5	1	0	-
Zelo Buon Peresico	LO	0.56	0.44	18	0.298	0.813	375	95	8.95	29.42	13,758	2.49	39.6	1,350	3	1	0	
Agrate Brianza	MB	0.65	0.35	20	0.251	0.820	1,332	165	13.42	32.72	16,646	2.43	42.0	2,075	5	1	0	
Aicurzio	MB	0.72	0.28	19	0.354	0.835	811	230	9.13	31.59	18,576	2.16	43.8	1,650	3	1	0	-
Albiate	MB	0.63	0.37	18	0.204	0.816	2,171	233	21.38	31.27	14,939	2.43	42.4	1,825	2	0	0	-
Arcore	MB	0.70	0.30	19	0.266	0.805	1,862	193	15.34	37.67	17,384	2.23	44.1	1,575	6	0	0	1.01
Barlassina	MB	0.66	0.34	18	0.135	0.785	2,382	227	30.87	31.56	14,983	2.36	43.2	1,400	5	1	0	-
Bellusco	MB	0.73	0.27	18	0.218	0.816	1,134	214	8.05	30.08	16,016	2.36	42.9	1,425	5	1	1	
Bernareggio	MB	0.66	0.34	17	0.224	0.800	1,818	234	10.22	34.56	16,682	2.29	41.2	1,275	3	0	1	-
Besana in Brianza	MB	0.64	0.36	17	0.227	0.800	989	335	21.34	33.73	15,960	2.50	43.4	1,500	3	0	0	-
Biassono	MB	0.67	0.34	18	0.220	0.831	2,451	202	19.62	36.98	17,092	2.37	43.9	1,450	1	1	0	
Bovisio-Masciago	MB	0.66	0.34	17	0.313	0.813	3,397	188	28.34	30.74	14,915	2.31	41.4	1,375	2	0	1	-
Briosco	MB	0.68	0.33	16	0.162	0.806	904	271	24.74	28.83	14,937	2.49	44.0	1,300	5	1	0	
Brugherio	MB	0.67	0.33	20	0.250	0.824	3,238	145	18.32	34.86	16,127	2.36	43.2	1,625	2	0	0	
Burago di Molgora	MB	0.70	0.30	18	0.254	0.828	1,256	182	10.79	37.47	17,423	2.34	45.0	1,275	2	1	0	
Busnago	MB	0.68	0.32	16	0.253	0.796	1,117	210	4.62	27.67	15,511	2.44	40.7	1,250	4		0	
Camparada	MB	0.66	0.34	15	0.278	0.851	1,319	243	16.64	40.69	17,060	2.58	41.6	1,300	5	0	0	
Caponago	MB	0.63	0.38	15	0.286	0.816	1,046	158	11.95	31.57	15,809	2.43	40.9	1,300	4	1	0	
Carate Brianza	MB	0.58	0.43	17	0.227	0.804	1,777	250	23.42	32.86	16,143	2.38	43.6	1,525	2	1	0	
Carnate	MB	0.67	0.33	18	0.222	0.824	2,089	237	12.37	40.32	16,894	2.38	44.1	1,325	3	0	1	
Cavenago di Brianza	MB	0.65	0.36	18	0.229	0.868	1,574	176	8.48	30.81	15,503	2.46	40.9	1,250	5	1	0	
Ceriano Laghetto	MB	0.68	0.32	16	0.256	0.810	910	216	34.48	28.2	14,931	2.36	42.2	1,075	2	1	0	
Cesano Maderno	MB	0.62	0.38	16	0.264	0.789	3,261	198	28.76	26.11	13,408	2.30	42.3	1,575	2	0	0	2.73
Cogliate	MB	0.63	0.37	15	0.175	0.795	1,220	236	34.65	26.84	14,489	2.50	42.4	1,175	2	1	0	
Concorezzo	MB	0.59	0.41	18	0.228	0.827	1,817	171	14.38	35.26	15,846	2.40	43.1	1,550	3	0	0	
Cornate d'Adda	MB	0.68	0.32	17	0.275	0.784	771	236	5.92	24.57	13,816	2.40	41.9	1,400	3		1	-
Correzzana	MB	0.65	0.35	17	0.264	0.817	1,098	255	17.96	40.31	18,328	2.36	40.0	1,100	2	1	0	-

Desio	MB	0.56	0.44	18	0.254	0.789	2,774	196	24.62	31.63	14,676	2.34	42.3	1,450	6	0	0	0.58
Giussano	MB	0.64	0.37	15	0.266	0.796	2,418	260	26.06	28.85	13,815	2.42	42.2	1,375	2	0	0	
Lazzate	MB	0.63	0.37	13	0.213	0.787	1,458	257	34.72	23.58	14,238	2.46	41.8	1,100	1	1	0	-
Lentate sul Seveso	MB	0.58	0.42	18	0.225	0.795	1,117	250	32.47	26.1	14,194	2.41	44.0	1,250	5		0	
Lesmo	MB	0.69	0.31	18	0.233	0.818	1,623	241	17.30	41.82	19,615	2.35	41.8	1,400	2	1	0	
Limbiate	MB	0.59	0.41	16	0.266	0.758	2,772	187	30.41	21.81	12,659	2.38	42.1	1,500	6	0	0	
Lissone	MB	0.59	0.41	18	0.335	0.789	4,784	191	21.31	31.71	15,030	2.32	41.9	1,600	1	1	1	1.91
Macherio	MB	0.60	0.41	15	0.216	0.815	2,233	215	20.91	28.59	17,269	2.33	44.2	1,350	2	0	0	-
Meda	MB	0.57	0.43	17	0.235	0.807	2,791	221	28.67	29.97	14,814	2.41	43.5	1,450	1	1	0	-
Mezzago	MB	0.63	0.38	14	0.303	0.821	1,012	219	6.51	23.94	13,640	2.34	41.4	1,275	5	1	0	-
Misinto	MB	0.66	0.34	18	0.204	0.788	1,030	252	34.52	24.91	15,290	2.52	41.0	1,225	2	1	0	-
Monza	MB	0.57	0.43	20	0.400	0.800	3,648	162	19.22	45.27	19,240	2.18	44.8	2,325	2	0	0	1.13
Muggiò	MB	0.62	0.38	16	0.235	0.813	4,286	186	22.92	30.7	14,767	2.45	43.1	1,450	2	0	0	0.11
Nova Milanese	MB	0.57	0.43	15	0.257	0.806	3,844	175	24.96	27.45	14,039	2.38	42.6	1,500	6	1	0	0.02
Ornago	MB	0.67	0.34	16	0.230	0.830	838	193	7.78	31.75	15,619	2.30	41.0	1,200	5	1	0	
Renate	MB	0.64	0.36	15	0.154	0.806	1,472	314	23.02	29.27	14,410	2.50	42.8	1,250	2	0	0	-
Roncello	MB	0.69	0.31	16	0.269	0.792	1,308	196	5.06	28.16	15,305	2.36	38.6	1,050	4	1	0	-
Ronco Briantino	MB	0.65	0.35	18	0.247	0.829	1,125	247	11.33	34.62	15,256	2.35	41.8	1,250	5	1	0	-
Seregno	MB	0.59	0.41	16	0.249	0.784	3,349	222	25.43	33.76	15,351	2.32	43.6	1,725	2	1	0	
Seveso	MB	0.61	0.40	16	0.277	0.805	3,126	211	29.40	28.76	14,333	2.42	42.0	1,475	2	1	0	
Sovico	MB	0.60	0.40	13	0.230	0.824	2,532	221	20.58	30.88	15,361	2.34	43.1	1,325	5	0	0	0.07
Sulbiate	MB	0.67	0.33	16	0.295	0.817	786	227	8.12	27.6	15,579	2.37	41.5	1,225	5	1	0	-
Triuggio	MB	0.59	0.41	15	0.225	0.824	1,041	231	20.57	30.61	16,207	2.42	42.6	1,200	2	1	0	
Usmate Velate	MB	0.66	0.34	19	0.236	0.821	1,014	221	13.23	36.8	16,791	2.39	41.4	1,100	5	1	0	
Varedo	MB	0.63	0.37	16	0.246	0.817	2,669	180	28.25	30.09	15,197	2.34	44.1	1,400	2	0	0	
Vedano al Lambro	MB	0.64	0.36	17	0.306	0.842	3,783	187	19.61	50.54	22,269	2.27	45.4	1,600	5	1	0	
Veduggio con Colzano	MB	0.71	0.29	17	0.183	0.793	1,275	305	24.25	24.33	14,188	2.50	43.3	1,125	2	1	0	
Verano Brianza	MB	0.67	0.33	16	0.165	0.816	2,661	264	24.85	28.79	14,188	2.47	42.9	1,425	5	1	0	
Villasanta	MB	0.67	0.34	19	0.242	0.817	2,804	173	16.30	38.17	16,948	2.35	44.5	1,425	2	0	0	-
Vimercate	MB	0.64	0.36	18	0.191	0.830	1,230	194	11.92	40.67	17,785	2.25	45.3	2,025	5	1	0	0.99
Abbiategrasso	MI	0.64	0.36	15	0.291	0.770	665	120	22.08	30.36	15,283	2.25	43.5	2,125	2	0	1	0.09
Albairate	MI	0.72	0.28	15	0.259	0.809	311	123	19.98	33.37	14,791	2.41	42.0	1,700	5	1	1	-
Arconate	MI	0.65	0.35	16	0.299	0.826	789	178	26.88	29.02	14,658	2.45	41.0	1,175	3	1	1	-
Arese	MI	0.64	0.36	17	0.246	0.825	2,923	160	11.71	52.84	22,409	2.34	44.6	1,850	2	1	1	
Arluno	MI	0.62	0.38	17	0.287	0.810	942	156	18.90	28.61	15,255	2.30	42.7	1,400	5	1	1	0.00
Assago	MI	0.43	0.57	16	0.230	0.849	1,013	109	8.63	44.8	18,151	2.41	41.1	2,025	2	0	0	33.43
Baranzate	MI	0.47	0.53	14	0.300	0.761	3,903	144	7.80	nd	11,737	2.09	41.3	1,450	4	1	0	
Bareggio	MI	0.62	0.38	17	0.307	0.801	1,538	138	14.13	32.03	15,954	2.37	43.1	1,450	2	0	1	
Basiano	MI	0.66	0.34	17	0.181	0.807	799	161	24.99	31.49	14,966	2.45	41.2	1,400	2	0	0	
Basiglio	MI	0.50	0.50	12	0.252	0.832	902	97	13.15	70.69	29,559	2.37	40.5	2,025	2	1	0	2.22
Bellinzago Lombardo	MI	0.70	0.30	17	0.264	0.834	853	129	21.95	36.31	15,800	2.39	42.8	1,250	5	1	0	-
Bernate Ticino	MI	0.76	0.24	17	0.312	0.845	254	130	28.31	25.62	15,378	2.34	44.0	1,190	2	1	1	
Besate	MI	0.79	0.21	13	0.338	0.793	163	104	24.49	22.69	13,441	2.26	43.0	1,090	3	1	1	
Binasco	MI	0.54	0.46	15	0.255	0.812	1,837	101	17.25	32.31	16,035	2.20	44.7	1,275	4	1	0	12.95
Boffalora sopra Ticino	MI	0.67	0.33	18	0.373	0.835	555	142	26.68	29.2	15,353	2.55	44.5	1,200	2	0	1	
Bollate	MI	0.61	0.39	18	0.205	0.801	2,703	156	9.08	29.65	15,417	2.26	44.3	1,875	2	0	0	0.58
Bresso	MI	0.58	0.42	17	0.424	0.801	7,619	142	6.95	38.32	16,407	2.18	46.2	2,075	6	1	0	
Bubbiano	MI	0.72	0.28	15	0.354	0.787	747	106	21.02	30.18	13,581	2.50	38.4	1,000	4	0	1	-
Buccinasco	MI	0.53	0.47	17	0.310	0.839	2,249	113	7.78	43.76	18,118	2.48	41.2	1,975	2	0	0	-
Buscate	MI	0.59	0.42	15	0.232	0.781	605	178	29.73	24.78	13,839	2.39	43.0	1,200	2	0	0	
Bussero	MI	0.68	0.32	17	0.253	0.843	1,874	141	16.26	43.29	17,168	2.41	43.6	1,575	5	1	1	
Busto Garolfo	MI	0.65	0.35	17	0.350	0.786	1,051	180	24.30	27.36	14,616	2.38	43.3	1,275	3	0	1	
Calvignasco	MI	0.81	0.19	15	0.361	0.822	641	105	20.37	35.41	13,713	2.61	39.6	1,000	4	0	1	-
Cambiago	MI	0.66	0.35	18	0.228	0.816	910	158	21.78	31.19	16,167	2.41	40.0	1,150	5	1	0	
Canegrate	MI	0.62	0.38	16	0.262	0.779	2,361	193	22.19	25.19	14,374	2.36	44.0	1,275	6	1	0	
Carpiano	MI	0.53	0.47	13	0.445	0.793	232	91	16.67	25.99	15,129	2.32	38.6	1,250	5	1	0	

Carugate	MI	0.69	0.31	19	0.248	0.822	2,689	149	15.11	32.42	15,402	2.42	41.1	1,650	5	1	0	0.73
Casarile	MI	0.59	0.41	15	0.239	0.799	540	97	18.60	28.13	13,824	2.39	39.6	1,040	3	1	0	
Casorezzo	MI	0.65	0.35	12	0.230	0.806	809	166	22.41	28.89	15,391	2.42	42.2	1,300	3	1	1	
Cassano d'Adda	MI	0.67	0.33	17	0.210	0.797	1,011	133	26.53	30.96	15,281	2.39	43.0	1,425	6	0	0	
Cassina de' Pecchi	MI	0.71	0.29	18	0.219	0.837	1,749	130	14.66	47.08	18,916	2.35	43.3	1,725	2	0	0	
Cassinetta di Lugagnano	MI	0.78	0.22	15	0.311	0.828	574	125	22.23	32.08	14,778	2.44	41.9	1,200	5	1	1	
Castano Primo	MI	0.50	0.50	16	0.280	0.794	581	182	32.71	27.93	13,968	2.37	43.5	1,300	3	0	0	
Cernusco sul Naviglio	MI	0.64	0.36	19	0.245	0.825	2,331	134	12.21	39.61	19,766	2.26	43.5	2,275	5	0	1	1.15
Cerro al Lambro	MI	0.68	0.32	16	0.240	0.842	492	84	20.44	38.29	16,752	1.98	42.5	1,175	5	0	1	-
Cerro Maggiore	MI	0.62	0.38	15	0.193	0.793	1,469	205	22.30	26.67	14,702	2.36	43.9	1,175	5	1	0	
Cesano Boscone	MI	0.51	0.49	15	0.325	0.778	5,798	119	7.72	30.11	14,449	2.26	44.1	1,800	6	1	1	
Cesate	MI	0.64	0.36	15	0.215	0.790	2,458	194	15.61	29.06	14,655	2.43	41.7	1,500	6	0	0	
Cinisello Balsamo	MI	0.50	0.50	18	0.360	0.772	5,657	154	9.55	29.67	14,025	2.17	44.2	1,950	6	1	1	2.39
Cisliano	MI	0.73	0.27	16	0.331	0.838	304	128	15.27	34.23	17,074	2.38	41.3	1,300	5	0	1	
Cologno Monzese	MI	0.51	0.49	20	0.274	0.772	5,340	131	9.96	29.85	13,850	2.28	43.7	2,075	6	0	0	0.77
Colturano	MI	0.62	0.38	13	0.279	0.798	473	92	16.31	33.44	14,415	2.45	39.5	1,150	5	1	0	-
Corbetta	MI	0.61	0.39	18	0.295	0.814	957	140	20.65	31.96	16,379	2.38	41.4	1,575	2	0	1	
Cormano	MI	0.56	0.44	17	0.255	0.802	4,507	149	7.08	29.69	15,268	2.27	43.3	1,850	6	1	1	
Cornaredo	MI	0.58	0.42	16	0.261	0.818	1,471	140	12.26	32.82	15,679	2.35	43.2	1,725	2	0	1	1.79
Corsico	MI	0.57	0.43	16	0.313	0.771	6,411	115	7.64	28.94	14,475	2.15	45.3	1,875	6	1	1	
Cuggiono	MI	0.68	0.32	16	0.190	0.817	555	157	28.71	27.91	14,630	2.39	43.1	1,050	2	1	0	-
Cusago	MI	0.60	0.40	16	0.308	0.870	319	126	11.54	51.69	25,078	2.46	41.3	1,625	3	1	1	15.96
Cusano Milanino	MI	0.67	0.33	18	0.275	0.808	6,032	152	8.56	35.57	17,331	2.09	46.8	2,075	2	0	1	
Dairago	MI	0.62	0.38	14	0.247	0.818	1,071	194	26.71	26.12	14,322	2.51	41.2	1,200	3	1	0	-
Dresano	MI	0.63	0.37	15	0.229	0.831	884	92	17.98	36.2	16,222	2.41	42.4	1,325	4	1	0	
Gaggiano	MI	0.62	0.38	17	0.285	0.822	336	117	13.41	30.97	16,295	2.29	43.3	1,425	5	1	1	
Garbagnate Milanese	MI	0.56	0.44	16	0.232	0.781	2,992	179	13.97	32.02	14,764	2.36	43.5	1,325	3	0	1	0.86
Gessate	MI	0.65	0.35	20	0.253	0.807	1,130	144	21.57	36.31	16,798	2.51	39.8	1,425	5	1	0	
Gorgonzola	MI	0.68	0.32	19	0.284	0.812	1,828	133	18.52	38.5	17,001	2.27	42.9	1,650	2	0	1	0.89
Grezzago	MI	0.66	0.34	15	0.224	0.794	1,170	180	27.78	25.62	13,033	1.97	39.0	990	4	1	1	
Gudo Visconti	MI	0.64	0.36	16	0.253	0.859	286	111	18.08	34.46	14,956	2.59	40.6	1,100	3	1	0	-
Inveruno	MI	0.72	0.28	14	0.214	0.819	705	161	25.99	29.11	15,269	2.37	45.1	1,275	3	1	0	0.20
Inzago	MI	0.70	0.30	17	0.224	0.824	881	137	24.57	31.08	16,063	2.31	43.5	1,350	4	1	1	
Lacchiarella	MI	0.58	0.42	19	0.260	0.797	358	98	17.20	25.18	15,080	2.32	42.9	1,350	5	1	0	
Lainate	MI	0.63	0.37	16	0.198	0.804	1,948	176	16.88	31.22	16,499	2.40	42.8	1,425	5	1	1	1.00
Legnano	MI	0.62	0.38	16	0.310	0.786	3,292	199	25.05	39.9	17,114	2.28	43.6	1,500	2	1	1	2.06
Liscate	MI	0.62	0.39	19	0.278	0.813	437	115	18.09	29.41	14,863	2.46	39.5	1,425	5	0	0	
Locate di Triulzi	MI	0.56	0.44	15	0.274	0.812	799	96	13.61	24.45	14,966	2.29	41.3	1,600	5	1	0	
Magenta	MI	0.68	0.32	17	0.242	0.802	1,051	138	23.28	33.49	15,957	2.29	44.9	1,750	2	1	0	0.53
Magnago	MI	0.63	0.37	17	0.277	0.795	811	197	31.41	27.45	14,661	2.39	42.2	1,200	2	1	0	
Marcallo con Casone	MI	0.61	0.39	15	0.305	0.811	755	147	24.07	27.71	15,435	2.45	43.1	1,350	1	1	1	-
Masate	MI	0.69	0.32	16	0.237	0.849	803	153	24.27	37.63	15,226	2.33	40.2	1,325	3	0	0	
Mediglia	MI	0.54	0.46	14	0.270	0.805	553	95	14.09	30.55	14,273	2.42	40.6	1,250	3	0	0	
Melegnano	MI	0.56	0.45	18	0.363	0.791	3,456	88	17.20	31.96	16,039	2.08	44.7	1,900	2	0	1	
Melzo	MI	0.62	0.38	19	0.274	0.788	1,887	118	19.26	30	15,415	2.21	45.0	1,775	5	1	1	1.14
Mesero	MI	0.69	0.31	15	0.292	0.819	708	154	25.50	28.11	14,903	2.33	43.1	1,050	5	1	1	
Milano	MI	0.37	0.63	16	0.372	0.771	6,932	122	-	48.16	22,675	1.71	45.8	4,900	6	0	0	7.87
Morimondo	MI	0.68	0.32	15	0.436	0.754	46	109	22.12	28.1	12,608	2.02	42.7	1,100	3	0	1	
Motta Visconti	MI	0.76	0.24	18	0.364	0.793	775	100	25.39	26.84	13,741	2.41	42.7	1,190	5	1	1	-
Nerviano	MI	0.73	0.27	18	0.219	0.792	1,286	175	18.16	30.13	15,603	2.34	44.6	1,375	5	1	1	0.53
Nosate	MI	0.68	0.32	7	0.266	0.847	141	177	36.35	23.36	14,475	2.22	46.0	1,125	5	1	0	-
Novate Milanese	MI	0.63	0.38	15	0.246	0.819	3,683	148	7.06	35.4	16,487	2.24	45.3	2,200	6	0	0	
Noviglio	MI	0.52	0.48	9	0.205	0.818	275	105	15.76	32.34	16,488	2.35	38.4	1,065	4	1	0	-
Opera	MI	0.51	0.49	14	0.236	0.833	1,730	101	11.70	41.33	18,268	2.15	44.5	1,825	2	0	0	3.86
Ossona	MI	0.64	0.36	15	0.242	0.811	699	156	22.68	25.9	14,488	2.42	43.0	1,075	5	1	0	
Ozzero	MI	0.69	0.31	10	0.483	0.818	136	107	23.44	25.05	13,990	2.33	42.3	975	5	1	1	

Paderno Dugnano	MI	0.53	0.47	16	0.239	0.810	3,313	163	10.86	29.56	15,313	2.33	43.6	1,725	2	0	0	
Pantigliate	MI	0.67	0.33	16	0.247	0.814	1,020	102	14.19	31.22	15,165	2.37	41.9	1,300	5	1	1	-
Parabiago	MI	0.64	0.37	17	0.275	0.782	1,885	184	20.27	31.93	15,839	2.30	43.4	1,200	2	1	0	0.40
Paullo	MI	0.70	0.30	16	0.334	0.799	1,252	97	18.09	28.92	14,355	2.38	42.5	1,250	5	1	1	
Pero	MI	0.47	0.54	15	0.254	0.783	2,065	144	8.19	27.9	15,065	2.14	43.8	1,875	5	1	1	14.37
Peschiera Borromeo	MI	0.58	0.42	17	0.307	0.824	959	101	11.16	45.39	20,387	2.29	42.2	1,600	2	0	1	7.92
Pessano con Bornago	MI	0.64	0.36	17	0.312	0.838	1,366	148	17.66	33.78	15,464	2.47	41.2	1,400	5	1	1	-
Pieve Emanuele	MI	0.42	0.58	19	0.334	0.774	1,146	97	15.08	35.25	14,937	2.27	40.9	1,550	2	0	1	
Pioltello	MI	0.55	0.46	16	0.242	0.770	2,729	122	11.48	27.77	12,986	2.29	40.4	1,800	6	1	0	
Pogliano Milanese	MI	0.66	0.34	17	0.251	0.801	1,744	164	15.76	30.1	15,688	2.45	42.7	1,350	1	0	1	0.09
Pozzo d'Adda	MI	0.63	0.37	16	0.220	0.779	1,385	164	27.31	31.05	14,793	2.32	39.3	1,250	5	1	0	-
Pozzuolo Martesana	MI	0.73	0.27	18	0.205	0.817	662	121	21.88	28.95	15,853	2.34	42.0	1,375	5	1	0	
Pregnana Milanese	MI	0.62	0.38	13	0.267	0.822	1,418	154	14.21	30.91	15,740	2.30	42.5	1,225	5	1	0	
Rescaldina	MI	0.60	0.41	16	0.298	0.789	1,709	220	23.55	30.3	15,748	2.33	43.2	1,250	2	1	0	0.04
Rho	MI	0.61	0.39	18	0.232	0.781	2,249	158	12.53	34.26	16,148	2.14	44.5	1,975	6	0	1	3.46
Robecchetto con Induno	MI	0.71	0.30	14	0.250	0.798	350	172	32.77	24.16	14,122	2.45	43.3	1,050	5	1	0	
Robecco sul Naviglio	MI	0.59	0.41	15	0.289	0.813	338	129	23.38	31.16	16,333	2.42	42.2	1,055	3	1	1	
Rodano	MI	0.70	0.30	17	0.242	0.858	363	112	13.47	43.8	18,009	2.50	41.5	1,125	2	1	0	
Rosate	MI	0.66	0.35	16	0.223	0.824	288	107	18.75	30.45	15,054	2.36	42.2	1,225	5	0	0	
Rozzano	MI	0.43	0.57	15	0.408	0.782	3,299	103	10.59	26.36	13,533	2.23	42.7	1,850	5	1	1	0.24
San Colombano al Lambro	MI	0.56	0.44	18	0.224	0.784	445	80	40.34	29.75	14,474	2.26	46.0	905	2	1	0	-
San Donato Milanese	MI	0.55	0.45	19	0.258	0.820	2,433	102	9.60	53.33	22,387	2.18	44.0	2,225	3	0	1	12.57
San Giorgio su Legnano	MI	0.62	0.38	14	0.215	0.796	2,907	198	23.45	28.86	15,187	2.35	43.6	2,225	1	0	0	
San Giuliano Milanese	MI	0.46	0.54	15	0.278	0.775	1,187	98	12.59	29.32	14,518	2.26	41.7	1,550	6	1	0	
Santo Stefano Ticino	MI	0.60	0.40	15	0.251	0.806	2,399	152	20.48	28.91	15,079	2.35	43.3	1,150	5	1	0	
San Vittore Olona	MI	0.67	0.33	14	0.213	0.824	583	197	22.29	32.32	14,028	2.44	40.3	1,350	1	0	0	
San Zenone al Lambro	MI	0.67	0.33	15	0.245	0.812	976	83	21.44	34.08	16,102	2.39	41.1	1,200	2	0	0	
Sedriano	MI	0.58	0.42	17	0.240	0.792	1,470	145	16.61	29.74	14,936	2.40	41.5	1,275	2	0	1	
Segrate	MI	0.57	0.43	17	0.244	0.831	1,929	115	9.52	53.21	23,208	2.24	43.7	2,375	2	1	0	5.42
Senago	MI	0.59	0.41	19	0.269	0.796	2,447	176	11.94	24.78	14,105	2.36	41.9	1,425	2	0	0	
Sesto San Giovanni	MI	0.38	0.62	17	0.327	0.773	6,541	140	8.51	36.14	16,217	1.98	45.7	2,450	6	1	0	3.28
Settala	MI	0.65	0.36	16	0.294	0.831	420	108	16.31	27.43	14,222	2.46	39.9	1,250	5	1	0	
Settimo Milanese	MI	0.55	0.45	15	0.273	0.835	1,817	134	8.96	34.91	17,109	2.32	42.4	1,600	6	1	1	
Solaro	MI	0.62	0.38	15	0.248	0.798	2,097	211	17.13	26.54	13,649	2.50	40.7	1,450	5	1	0	-
Trezzano Rosa	MI	0.67	0.33	16	0.247	0.810	1,429	170	26.62	33.27	15,436	2.42	39.1	1,275	5	1	0	
Trezzano sul Naviglio	MI	0.50	0.50	15	0.287	0.807	1,880	116	10.66	36.08	16,086	2.57	42.8	1,450	2	0	0	5.23
Trezzo sull'Adda	MI	0.72	0.28	20	0.203	0.802	934	187	29.97	29.25	14,778	2.27	44.3	1,300	2	0	1	2.25
Tribiano	MI	0.50	0.50	16	0.308	0.845	491	93	16.27	33.35	16,570	2.27	37.8	1,100	3	0	0	
Truccazzano	MI	0.60	0.40	17	0.306	0.812	272	108	22.47	25.66	14,724	2.32	40.2	1,225	3	1	0	-
Turbigo	MI	0.58	0.42	15	0.250	0.796	870	146	34.72	27.03	12,834	2.37	44.2	1,050	3	1	1	
Vanzaghello	MI	0.61	0.39	17	0.296	0.797	976	194	33.16	26	14,188	2.54	43.0	1,175	5	1	1	
Vanzago	MI	0.63	0.37	16	0.252	0.828	1,445	161	15.61	33.32	16,565	2.29	41.1	1,200	5	1	0	
Vaprio d'Adda	MI	0.69	0.31	17	0.243	0.811	1,193	161	29.08	29.97	15,055	2.36	41.6	1,225	3	1	0	
Vermezzo	MI	0.64	0.36	15	0.179	0.828	639	119	18.06	37.35	15,357	2.46	39.2	1,125	3	1	0	
Vernate	MI	0.63	0.37	16	0.258	0.809	221	103	20.11	22.82	15,526	2.30	40.8	1,090	5	1	0	
Vignate	MI	0.67	0.33	18	0.212	0.829	1,056	121	15.44	31.34	15,165	2.46	40.9	1,450	4	1	0	
Villa Cortese	MI	0.66	0.34	16	0.237	0.828	1,740	190	24.99	24.79	14,270	2.48	44.0	1,025	5	1	1	
Vimodrone	MI	0.60	0.40	18	0.290	0.805	3,500	128	9.27	30.79	16,426	2.18	42.6	1,525	5	1	0	
Vittuone	MI	0.64	0.37	17	0.316	0.819	1,496	146	17.83	31.03	14,778	2.52	41.8	1,150	2	1	1	
Vizzolo Predabissi	MI	0.64	0.36	17	0.215	0.852	706	90	18.72	37.92	17,162	2.77	43.7	1,250	5	1	0	-
Zelo Surrigone	MI	0.68	0.33	16	0.164	0.853	366	113	18.16	33.37	15,343	2.64	38.0	1,050	3	1	0	-
Zibido San Giacomo	MI	0.57	0.44	17	0.317	0.825	267	103	12.94	28.84	14,349	2.38	39.1	1,250	5	1	1	
Acquanegra sul Chiese	MN	0.76	0.24	14	0.277	0.804	107	31	17.00	19.63	11,052	2.49	45.2	525	4	0	0	
Asola	MN	0.73	0.27	17	0.290	0.806	137	42	17.00	23.65	12,019	2.54	43.4	700	2	0	1	
Bagnolo San Vito	MN	0.86	0.14	18	0.237	0.815	121	19	40.00	24.86	12,082	2.26	44.6	600	3	1	1	2.61
Bigarello	MN	0.80	0.20	11	0.272	0.800	77	23	37.00	25.84	13,899	2.29	43.6	600	5	1	1	0.21

Borgoforte	MN	0.85	0.15	15	0.298	0.781	91	19	30.00	21.78	11,447	2.52	43.8	600	3	1	1	0.21
Borgofranco sul Po	MN	0.83	0.17	14	0.295	0.792	53	14	68.00	20.13	10,463	2.46	50.8	550	5	1	0	-
Bozzolo	MN	0.84	0.17	16	0.214	0.819	223	30	28.00	25.14	13,363	2.41	45.3	600	2	1	1	
Canneto sull'Oglio	MN	0.66	0.34	14	0.275	0.776	176	34	22.00	20.63	11,233	2.48	44.4	600	3	1	0	0.52
Carbonara di Po	MN	0.82	0.18	15	0.285	0.809	87	14	70.00	26.59	11,652	2.38	46.8	600	3	0	0	
Casalmoro	MN	0.59	0.41	9	0.156	0.789	162	47	17.00	15.39	10,751	2.64	39.8	600	5	0	1	
Casaloldo	MN	0.76	0.24	13	0.322	0.803	156	45	10.00	18.72	12,107	2.62	41.0	550	4	1	0	
Casalromano	MN	0.68	0.32	7	0.244	0.800	130	42	23.00	20.56	10,065	2.52	41.7	525	4	1	0	-
Castelbelforte	MN	0.45	0.55	15	0.221	0.788	216	24	34.00	20.26	11,964	2.48	42.7	625	4	1	0	-
Castel d'Ario	MN	0.45	0.55	15	0.166	0.795	294	53	41.00	22.89	11,903	2.50	43.2	675	5	0	0	1.28
Castel Goffredo	MN	0.33	0.67	14	0.196	0.818	139	27	9.00	21.93	12,437	2.44	39.3	650	2	1	0	2.89
Castellucchio	MN	0.53	0.47	13	0.095	0.808	112	26	15.00	23.68	12,114	2.47	44.0	625	4	1	0	0.22
Castiglione delle Stiviere	MN	0.74	0.26	17	0.248	0.796	537	116	17.00	29.96	13,170	2.50	40.4	925	2	1	1	1.18
Cavriana	MN	0.65	0.35	14	0.254	0.810	105	170	12.00	18.37	10,917	2.71	43.6	750	5		0	1.03
Ceresara	MN	0.83	0.17	14	0.287	0.813	72	44	-	20.35	12,291	2.75	42.6	600	2	1	1	1.25
Commessaggio	MN	0.44	0.57	11	0.207	0.827	101	22	32.00	21.38	11,559	2.47	47.0	600	5	1	0	-
Curtatone	MN	0.84	0.16	19	0.267	0.827	217	26	21.00	34.11	14,900	2.41	43.4	900	4	0	1	0.36
Dosolo	MN	0.87	0.13	15	0.191	0.812	133	25	45.00	24.71	12,613	2.50	44.8	625	3	0	1	
Felonica	MN	0.86	0.14	16	0.312	0.799	64	11	83.00	24.73	11,107	2.23	51.1	550	5	1	0	
Gazoldo degli Ippoliti	MN	0.87	0.13	14	0.273	0.803	231	35	10.00	23.17	13,954	2.65	42.6	650	3	0	0	
Gazzuolo	MN	0.41	0.60	13	0.198	0.800	108	25	32.00	22.89	11,683	2.44	47.6	600	5	1	0	
Goito	MN	0.86	0.14	16	0.212	0.810	132	33	9.00	22.53	11,901	2.57	44.1	750	3	1	1	0.06
Gonzaga	MN	0.81	0.19	16	0.201	0.830	182	22	49.00	26.61	11,197	2.64	42.1	700	5	1	1	0.27
Guidizzolo	MN	0.58	0.42	17	0.237	0.809	275	61	7.00	21.24	10,936	2.63	42.1	700	3	1	1	
Magnacavallo	MN	0.87	0.13	15	0.340	0.798	57	11	71.00	21.59	9,671	2.44	47.2	550	3	1	0	-
Mantova	MN	0.41	0.59	19	0.320	0.783	738	19	17.00	41.53	17,363	2.00	47.4	1,450	2	1	1	3.54
Marcaria	MN	0.43	0.57	12	0.206	0.783	76	25	22.00	21.73	12,476	2.46	46.6	625	5	1	1	0.25
Mariana Mantovana	MN	0.85	0.15	11	0.050	0.839	82	36	12.00	16.14	10,950	2.55	42.0	600	3	1	0	-
Marmirolo	MN	0.82	0.18	17	0.225	0.813	186	29	17.00	23.87	12,852	2.46	44.0	800	2	0	1	0.60
Medole	MN	0.76	0.24	12	0.257	0.789	158	62	10.00	19.66	11,440	2.61	41.6	600	5	0	0	
Moglia	MN	0.48	0.53	14	0.161	0.812	184	20	58.00	23.39	10,861	2.44	45.2	550	4	1	0	
Monzambano	MN	0.74	0.26	14	0.250	0.839	162	88	21.00	23.64	11,772	2.42	43.2	825	5	0	0	5.85
Motteggiana	MN	0.84	0.16	14	0.362	0.827	105	20	32.00	23.79	11,621	2.58	41.3	700	5	0	1	
Ostiglia	MN	0.80	0.20	17	0.272	0.793	172	13	60.00	30.33	12,292	2.21	46.4	600	5	0	1	2.16
Pegognaga	MN	0.81	0.19	17	0.275	0.844	155	22	44.00	22.8	11,080	2.59	43.9	650	5	1	1	1.26
Pieve di Coriano	MN	0.71	0.29	15	0.336	0.879	83	16	64.00	20.97	11,994	2.27	44.0	625	5	1	0	
Piubega	MN	0.84	0.16	17	0.225	0.794	108	40	5.00	19.62	11,251	2.65	43.8	525	3	1	0	-
Poggio Rusco	MN	0.51	0.49	16	0.231	0.788	153	16	71.00	27.61	10,892	2.37	45.3	625	4	1	1	
Pomponesco	MN	0.46	0.54	14	0.256	0.778	140	23	53.00	20.38	11,779	2.68	44.7	600	2	1	0	
Ponti sul Mincio	MN	0.69	0.31	14	0.262	0.823	198	113	24.00	23.52	13,694	2.33	42.6	850	3	0	0	11.51
Porto Mantovano	MN	0.85	0.15	19	0.321	0.832	434	29	23.00	33.44	14,146	2.40	43.7	800	5	1	1	0.75
Quingentole	MN	0.82	0.18	12	0.383	0.832	84	16	56.00	20.55	9,797	2.29	45.9	550	3	1	0	0.21
Quistello	MN	0.65	0.35	18	0.234	0.808	124	17	54.00	25.49	11,182	2.30	47.4	725	4	1	0	
Redondesco	MN	0.84	0.16	17	0.351	0.797	69	31	15.00	20.36	11,089	2.50	46.6	600	1	0	0	-
Revere	MN	0.33	0.67	13	0.253	0.805	179	16	60.00	27.38	12,857	2.28	47.4	625	4		0	-
Rivarolo Mantovano	MN	0.51	0.49	14	0.233	0.797	102	26	38.00	22.56	12,788	2.52	45.8	1,025	3	1	0	-
Rodigo	MN	0.74	0.26	15	0.171	0.808	130	31	10.00	22.08	12,859	2.52	45.3	625	2	0	0	3.57
Roncoferraro	MN	0.66	0.34	18	0.297	0.806	114	25	41.00	22.82	12,818	2.49	45.5	575	5	1	0	0.14
Roverbella	MN	0.81	0.20	17	0.271	0.802	136	48	16.00	21.96	11,703	2.57	42.9	700	4	1	1	0.08
Sabbioneta	MN	0.83	0.17	17	0.208	0.800	116	18	40.00	22.6	12,591	2.46	45.8	750	3	0	0	
San Benedetto Po	MN	0.42	0.58	17	0.211	0.814	110	19	44.00	23.17	10,585	2.51	46.3	700	5	1	1	0.22
San Giacomo delle Segnate	MN	0.71	0.29	17	0.282	0.774	109	16	61.00	25.39	9,488	3.01	46.1	550	4	1	0	
San Giorgio di Mantova	MN	0.85	0.15	16	0.265	0.819	390	21	29.00	31.05	13,832	2.37	42.2	800	5	1	1	1.51
San Giovanni del Dosso	MN	0.25	0.75	16	0.255	0.820	85	16	64.00	20.47	10,215	2.04	43.3	550	2	0	1	-
San Martino dall'Argine	MN	0.80	0.20	12	0.263	0.759	106	29	25.00	20.21	12,365	2.40	47.2	600	3	1	1	-
Schivenoglia	MN	0.36	0.64	8	0.153	0.833	92	16	60.00	24.82	9,934	2.36	48.4	550	4	1	0	-

Sermide	MN	0.84	0.16	17	0.284	0.813	110	12	78.00	30.6	12,187	2.28	47.2	600	4	0	1	0.44
Serravalle a Po	MN	0.59	0.42	17	0.186	0.808	59	15	56.00	18.39	11,249	2.39	47.8	575	5	1	1	
Solferino	MN	0.75	0.25	12	0.328	0.812	198	124	16.00	22.77	14,065	2.40	43.6	750	3	1	1	5.50
Sustinente	MN	0.55	0.45	16	0.286	0.804	84	17	48.00	21.76	11,461	2.43	45.7	575	2	0	1	
Suzzara	MN	0.83	0.17	16	0.238	0.829	342	20	38.00	28.46	12,107	2.39	43.2	725	6	1	1	0.94
Viadana	MN	0.76	0.24	18	0.263	0.775	192	26	44.00	26.58	13,269	2.38	42.5	800	5	1	0	0.53
Villa Poma	MN	0.44	0.56	15	0.289	0.806	143	13	68.00	25.92	11,593	2.38	46.3	625	5	1	0	
Villimpenta	MN	0.40	0.60	14	0.238	0.762	149	18	47.00	17.25	11,474	2.38	46.0	600	5	1	0	-
Virgilio	MN	0.82	0.18	17	0.320	0.804	350	22	28.00	36.24	13,655	2.32	43.7	850	3	0	1	1.99
Volta Mantovana	MN	0.70	0.30	14	0.247	0.801	146	91	13.00	23.3	11,919	2.55	43.1	775	4	0	1	2.67
Alagna	PV	0.27	0.73	12	0.247	0.758	101	92	16.58	23	13,700	2.27	44.8	840	4	1	0	-
Albaredo Arnaboldi	PV	0.28	0.72	13	0.233	0.831	25	62	43.23	27.96	14,274	2.25	45.9	745	4	1	0	-
Albonese	PV	0.28	0.72	8	0.193	0.744	130	113	3.65	21.56	13,850	2.33	50.2	840	4	1	0	-
Albuzzano	PV	0.37	0.63	15	0.137	0.779	222	76	42.18	25.64	13,112	2.38	40.7	900	3	1	0	
Arena Po	PV	0.27	0.73	12	0.191	0.771	72	61	52.20	26.88	12,245	2.34	47.2	960	5	1	0	
Badia Pavese	PV	0.31	0.69	10	0.150	0.773	82	55	59.03	22.97	11,868	2.46	44.8	860	4	1	0	
Bagnaria	PV	0.24	0.76	6	0.256	0.814	41	333	58.41	24.01	12,661	2.07	49.2	745	4	1	0	
Barbianello	PV	0.24	0.76	12	0.192	0.823	76	67	42.30	31.28	13,187	2.38	45.3	840	3	1	0	-
Bascapè	PV	0.39	0.61	11	0.126	0.804	127	89	44.11	29.61	12,844	2.13	42.7	860	5	1	0	
Bastida de' Dossi	PV	0.23	0.77	9	0.189	0.830	101	77	30.10	23.57	14,554	2.22	46.1	745	4	1	0	
Bastida Pancarana	PV	0.47	0.53	13	0.160	0.822	78	67	34.08	29.69	13,252	2.29	45.1	780	5	1	0	-
Battuda	PV	0.16	0.84	15	0.129	0.785	90	98	25.62	26.8	15,136	2.15	40.2	935	3	1	0	-
Belgioioso	PV	0.45	0.55	12	0.218	0.756	256	75	46.17	27.89	12,717	2.33	44.4	980	5	1	0	
Bereguardo	PV	0.66	0.34	18	0.180	0.799	157	98	21.81	27.24	15,072	2.16	44.3	1,090	2	0	0	
Borgarello	PV	0.53	0.47	18	0.204	0.827	553	88	30.85	39.51	17,667	2.52	39.6	1,100	4	0	0	
Borgo Priolo	PV	0.16	0.84	9	0.247	0.890	48	144	46.90	28.9	13,197	2.18	47.7	865	4	1	0	1.36
Borgoratto Mormorolo	PV	0.37	0.63	8	0.186	0.786	60	98	52.30	25.44	12,232	2.08	49.5	770	4		0	
Borgo San Siro	PV	0.19	0.81	9	0.259	0.753	27	326	13.76	19.46	11,960	1.95	44.3	840	4	1	1	-
Bornasco	PV	0.36	0.64	14	0.184	0.813	207	85	36.60	28.46	13,752	2.49	37.8	995	5	1	0	-
Bosnasco	PV	0.24	0.76	13	0.195	0.838	133	124	53.44	24.1	15,269	2.38	47.6	865	4	1	0	
Brallo di Pregola	PV	0.06	0.94	4	0.368	0.578	14	951	73.47	16.67	11,760	1.63	60.4	780	4	1	0	9.42
Breme	PV	0.25	0.75	9	0.181	0.681	44	101	19.80	21.94	11,242	2.08	49.4	760	4	1	0	
Bressana Bottarone	PV	0.24	0.76	11	0.201	0.806	271	69	37.51	27.83	13,323	2.27	44.1	840	3	1	0	-
Broni	PV	0.28	0.72	15	0.222	0.769	445	88	46.77	30.25	13,422	2.17	47.3	1,030	5	1	1	1.43
Calvignano	PV	0.24	0.76	11	0.252	0.771	19	275	46.69	23.85	21,309	2.24	47.5	780	4	1	0	
Campospinoso	PV	0.22	0.78	11	0.199	0.732	274	64	43.90	25.52	13,014	2.63	49.1	745	4	1	0	-
Candia Lomellina	PV	0.24	0.76	9	0.192	0.753	58	102	16.80	25.62	12,567	2.13	47.5	840	4	1	0	-
Canevino	PV	0.24	0.76	11	0.236	0.719	23	410	55.62	26.89	11,663	1.79	55.3	780	4	1	0	
Canneto Pavese	PV	0.24	0.76	13	0.204	0.802	245	233	48.74	30	13,178	2.13	48.0	780	4	1	0	0.64
Carbonara al Ticino	PV	0.64	0.36	12	0.134	0.808	107	83	27.58	28.04	14,930	2.23	43.6	900	5	1	0	
Casanova Lonati	PV	0.24	0.76	12	0.186	0.793	106	64	41.85	24.87	12,383	2.34	44.5	745	4	1	0	-
Casatisma	PV	0.23	0.77	7	0.178	0.808	165	77	39.57	22.72	12,814	2.26	45.9	780	4	1	0	
Casei Gerola	PV	0.25	0.75	11	0.160	0.793	101	81	33.52	27.07	13,386	2.34	46.6	1,080	5	0	0	
Casorate Primo	PV	0.61	0.40	18	0.265	0.795	895	103	21.08	23.76	12,896	2.39	41.7	1,575	5	1	1	
Cassolnovo	PV	0.26	0.74	9	0.223	0.750	218	120	9.87	23.85	13,447	2.26	43.6	1,090	2	1	0	
Castana	PV	0.24	0.76	14	0.214	0.805	142	290	49.80	26.04	12,769	2.08	49.1	780	4	0	0	
Casteggio	PV	0.17	0.83	11	0.219	0.752	386	90	42.00	33.44	14,470	2.16	48.0	1,005	2	0	0	0.01
Castelletto di Branduzzo	PV	0.33	0.67	8	0.310	0.799	91	70	36.09	28.41	13,289	2.15	45.8	780	4		0	17.92
Castello d'Agogna	PV	0.28	0.72	11	0.208	0.799	105	106	7.28	23.51	14,178	2.48	43.7	760	4	1	0	
Castelnovetto	PV	0.31	0.69	8	0.163	0.725	33	111	11.29	20.11	12,439	2.29	48.1	760	4	1	0	-
Cava Manara	PV	0.70	0.30	18	0.231	0.808	383	79	32.07	33.69	15,238	2.33	43.4	1,150	5	1	0	
Cecima	PV	0.19	0.81	8	0.296	0.799	23	331	54.54	28.28	13,206	1.82	51.2	795	4	1	0	
Ceranova	PV	0.37	0.63	15	0.135	0.811	436	86	38.62	29.73	13,083	2.48	37.3	860	5	1	0	-
Ceretto Lomellina	PV	0.27	0.73	5	0.172	0.813	27	109	7.41	21.69	10,847	1.96	48.4	760	4	0	0	-
Cergnago	PV	0.26	0.75	8	0.227	0.810	55	100	9.48	21.71	12,845	2.16	47.9	760	4	1	0	-
Certosa di Pavia	PV	0.68	0.32	19	0.096	0.797	478	89	30.00	28.55	15,270	2.24	40.5	1,025	5	1	0	3.28

Cervesina	PV	0.22	0.78	10	0.146	0.803	97	72	32.20	24.36	12,230	2.32	47.2	820	4	0	0	
Chignolo Po	PV	0.33	0.67	10	0.251	0.737	176	68	59.13	24.34	11,635	2.41	43.1	1,150	4	1	0	
Cigognola	PV	0.25	0.75	14	0.234	0.783	171	309	47.65	26.31	12,217	2.26	50.0	890	3	0	1	
Cilavegna	PV	0.44	0.56	13	0.206	0.745	314	115	3.13	23.46	12,525	2.39	44.1	895	2	0	0	-
Codevilla	PV	0.18	0.82	9	0.211	0.829	78	146	42.76	31.66	15,611	2.12	47.6	690	4	1	0	
Confienza	PV	0.26	0.74	10	0.162	0.772	62	126	16.21	17.9	12,214	2.23	46.8	760	4	1	0	
Copiano	PV	0.38	0.62	10	0.168	0.807	416	74	45.77	19.49	13,251	2.24	42.8	885	4	0	0	-
Corana	PV	0.30	0.70	8	0.182	0.774	63	71	29.87	25.04	13,316	2.45	48.8	745	4	0	0	-
Cornale	PV	0.24	0.76	6	0.169	0.747	427	74	29.48	24.77	14,575	2.05	49.0	865	4	1	0	
Corteolona	PV	0.35	0.65	10	0.159	0.756	218	71	50.39	23.91	13,129	2.32	42.2	895	4	1	0	-
Corvino San Quirico	PV	0.27	0.73	13	0.155	0.799	238	218	44.19	28.7	14,316	2.15	49.9	825	4	1	0	
Costa de' Nobili	PV	0.47	0.53	12	0.146	0.774	31	66	51.93	20.37	12,838	2.13	46.8	875	4	1	0	-
Cozzo	PV	0.27	0.73	6	0.172	0.711	21	105	14.81	22.07	12,300	1.90	50.7	840	5	1	0	-
Cura Carpignano	PV	0.66	0.34	17	0.265	0.816	430	78	40.29	32.73	14,046	2.47	37.9	1,025	5	1	0	
Dorno	PV	0.35	0.65	11	0.186	0.760	151	90	21.14	23.08	13,301	2.27	44.5	865	3	1	0	-
Ferrera Erbognone	PV	0.28	0.73	11	0.132	0.751	59	89	20.61	20.76	12,294	2.03	44.6	785	4	1	0	
Filighera	PV	0.37	0.63	11	0.223	0.771	104	74	45.79	22.58	12,806	2.38	45.7	875	3	0	0	-
Fortunago	PV	0.19	0.81	6	0.245	0.686	22	482	52.57	24.81	13,264	1.75	54.5	865	4	1	0	1.75
Frascarolo	PV	0.29	0.71	10	0.156	0.770	51	87	26.74	19.23	10,673	2.20	48.6	840	3	0	0	
Galliavola	PV	0.28	0.72	6	0.168	0.544	25	90	21.21	18.5	11,770	2.53	49.1	760	4	1	0	-
Gambarana	PV	0.31	0.69	5	0.325	0.650	20	83	28.25	21.18	11,755	1.81	53.0	760	4	1	0	-
Gambolò	PV	0.31	0.69	12	0.250	0.754	191	106	8.56	23.84	12,566	2.29	42.8	1,140	2	0	0	0.38
Garlasco	PV	0.31	0.69	18	0.221	0.748	252	93	16.50	24.44	13,007	2.32	46.3	1,075	3	0	0	0.90
Genzone	PV	0.34	0.66	11	0.183	0.801	93	72	48.07	18.21	12,932	2.27	48.0	935	4	1	0	-
Gerenzago	PV	0.41	0.59	10	0.192	0.805	265	74	48.40	21.97	12,091	2.52	39.9	935	4	1	0	-
Giussago	PV	0.35	0.65	14	0.203	0.792	207	93	30.51	22.18	14,263	2.27	41.4	1,080	5	1	0	
Godiasco	PV	0.21	0.79	12	0.272	0.807	154	196	49.06	39.16	17,289	2.05	47.5	985	4	0	0	11.11
Golferenzo	PV	0.23	0.77	11	0.233	0.759	46	464	56.33	22.12	12,830	1.89	51.3	880	4	1	0	
Gravellona Lomellina	PV	0.30	0.70	11	0.194	0.759	135	118	5.14	26.14	13,321	2.22	43.5	970	3	1	0	
Gropello Cairoli	PV	0.52	0.48	11	0.192	0.788	179	89	22.15	26	13,491	2.46	45.1	795	3	1	0	1.20
Inverno e Monteleone	PV	0.32	0.68	11	0.162	0.798	148	74	50.54	22.53	13,999	2.32	44.4	935	4	1	0	
Landriano	PV	0.45	0.55	11	0.174	0.815	388	88	39.96	27.03	13,994	2.28	40.4	1,300	5	1	0	
Langosco	PV	0.25	0.75	7	0.245	0.751	27	111	16.50	23.06	11,977	1.97	48.7	760	4	1	0	-
Lardirago	PV	0.34	0.66	13	0.256	0.744	226	83	38.04	28.59	13,230	2.19	45.1	905	3	0	0	-
Linarolo	PV	0.60	0.40	13	0.140	0.791	229	76	42.79	26.72	13,714	2.38	42.0	1,080	4	0	0	-
Lirio	PV	0.24	0.77	12	0.324	0.727	78	257	50.97	16.42	8,419	1.86	49.4	780	4	1	0	-
Lomello	PV	0.25	0.75	9	0.243	0.782	102	96	18.26	21.36	12,087	2.41	46.8	995	4	1	0	
Lungavilla	PV	0.31	0.69	10	0.223	0.786	353	75	37.32	27.04	14,268	2.24	45.6	880	4	1	0	-
Magherno	PV	0.38	0.62	11	0.158	0.787	339	76	45.76	19.78	12,415	2.32	43.3	885	4	1	0	-
Marcignago	PV	0.51	0.49	18	0.172	0.827	244	93	25.92	28.59	13,842	2.34	41.7	935	5	0	0	-
Marzano	PV	0.31	0.69	7	0.109	0.787	175	78	42.75	23.88	12,026	2.39	39.5	860	3	0	0	-
Mede	PV	0.40	0.61	12	0.269	0.753	209	93	20.57	23.51	12,538	2.29	46.4	995	2	1	0	
Menconico	PV	0.07	0.93	7	0.358	0.643	13	728	68.14	20.77	14,507	1.61	59.1	855	4	1	0	
Mezzana Bigli	PV	0.26	0.74	10	0.179	0.760	59	76	25.90	20.16	13,628	2.20	48.1	760	3	0	0	
Mezzana Rabattone	PV	0.56	0.44	9	0.119	0.852	71	68	30.28	25.17	12,193	2.19	47.5	825	4	1	0	-
Mezzanino	PV	0.24	0.76	11	0.206	0.788	106	62	40.00	25.06	14,249	2.18	46.8	840	4	1	0	
Miradolo Terme	PV	0.61	0.39	15	0.180	0.773	396	72	55.77	23.95	12,773	2.35	43.0	1,150	5	0	0	
Montalto Pavese	PV	0.24	0.76	14	0.245	0.788	48	380	49.77	26.33	11,378	1.95	49.0	780	3	0	0	0.51
Montebello della Battaglia	PV	0.36	0.64	8	0.137	0.805	105	110	41.77	30.21	13,473	2.35	47.6	840	5	1	0	0.14
Montecalvo Versiggia	PV	0.24	0.76	11	0.153	0.760	50	360	54.31	32.86	11,740	1.98	49.2	780	4	1	0	0.21
Montescano	PV	0.27	0.73	14	0.197	1.000	162	137	51.30	34.51	14,075	1.95	46.6	780	3	1	0	
Montesegale	PV	0.24	0.76	10	0.270	0.740	20	426	51.08	27.8	15,163	2.15	53.9	795	4	1	0	-
Monticelli Pavese	PV	0.31	0.69	11	0.178	0.740	34	53	62.64	19.01	10,797	2.21	46.8	860	4	1	0	
Montù Beccaria	PV	0.24	0.76	13	0.236	0.791	112	277	52.00	31.46	12,572	2.08	47.3	865	4	1	0	
Mornico Losana	PV	0.24	0.76	12	0.219	0.733	83	284	46.81	32.45	13,073	2.01	49.7	820	4	1	0	
Mortara	PV	0.34	0.66	11	0.297	0.739	297	108	4.07	30.37	13,490	2.30	45.2	1,075	1	0	0	0.43

Nicorvo	PV	0.33	0.67	9	0.230	0.662	44	115	6.49	22.29	9,800	2.03	47.5	760	4	1	0	-
Olevano di Lomellina	PV	0.24	0.76	8	0.256	0.789	51	108	8.09	20.73	12,129	2.36	45.6	760	3	0	0	
Oliva Gessi	PV	0.25	0.75	11	0.214	0.803	46	275	45.71	23.53	13,003	2.23	50.5	820	4	1	0	-
Ottobiano	PV	0.30	0.70	12	0.212	0.781	47	96	15.58	20.41	11,671	2.31	46.3	785	4	1	0	-
Palestro	PV	0.24	0.76	10	0.173	0.737	102	121	17.13	20.66	13,320	2.18	47.0	840	4	1	0	-
Pancarana	PV	0.40	0.60	6	0.144	0.776	51	68	32.96	26.48	13,072	2.12	48.3	780	3	1	0	-
Parona	PV	0.28	0.72	10	0.122	0.745	212	113	-	23.37	12,359	2.45	43.6	860	4	1	0	
Pavia	PV	0.34	0.66	22	0.254	0.793	1,087	77	33.94	46.72	19,850	1.88	47.3	2,275	2	0	0	1.40
Pietra de' Giorgi	PV	0.24	0.76	11	0.218	0.744	85	311	47.52	26.14	10,095	2.33	46.8	805	4	1	0	
Pieve Albignola	PV	0.33	0.67	12	0.189	0.758	52	85	25.08	21.94	12,411	2.41	46.0	785	4	1	0	-
Pieve del Cairo	PV	0.34	0.66	12	0.237	0.723	82	80	26.18	21.21	13,266	2.25	47.2	840	4	0	0	
Pieve Porto Morone	PV	0.37	0.63	12	0.192	0.788	169	58	23.08	20.76	11,593	2.37	46.3	885	3	1	0	-
Pinarolo Po	PV	0.24	0.76	12	0.242	0.852	154	67	40.29	25.28	12,807	2.30	46.5	805	5	1	1	
Pizzale	PV	0.45	0.55	7	0.149	0.799	99	78	35.83	29.77	14,432	2.14	48.6	745	4	1	0	-
Ponte Nizza	PV	0.17	0.83	11	0.228	0.745	36	267	54.97	26.71	12,430	2.13	51.0	840	4	1	0	
Portalbera	PV	0.24	0.76	12	0.187	0.822	328	64	49.00	29.39	12,545	2.43	44.2	855	4	1	0	-
Rea	PV	0.25	0.76	11	0.306	0.767	151	63	36.80	24.83	12,965	2.12	49.2	840	4	1	1	
Redavalle	PV	0.24	0.76	11	0.206	0.784	193	85	44.60	29.94	12,993	2.11	47.8	915	4	1	0	
Retorbido	PV	0.22	0.78	9	0.231	0.747	130	169	43.24	32.9	13,949	2.34	44.3	840	4		0	
Rivanazzano	PV	0.22	0.78	9	0.194	0.797	180	153	44.65	33.88	14,955	2.14	45.4	1,080	3		0	1.72
Robbio	PV	0.35	0.65	13	0.221	0.752	151	122	12.53	25.45	14,279	2.24	47.2	860	3	1	0	
Robecco Pavese	PV	0.25	0.75	13	0.256	0.862	80	75	40.69	25.61	14,122	2.31	47.2	805	4	1	0	-
Rocca de' Giorgi	PV	0.25	0.75	12	0.286	0.786	7	219	52.45	44.71	13,081	2.03	37.4	780	4	1	0	-
Rocca Susella	PV	0.20	0.80	9	0.231	0.704	18	348	48.43	29.58	13,847	1.77	50.5	795	4	1	0	
Rognano	PV	0.63	0.37	8	0.251	0.833	68	95	26.54	34.44	17,645	2.31	35.4	910	4	1	0	
Romagnese	PV	0.17	0.83	7	0.266	0.633	24	630	67.01	16.81	11,589	1.68	59.5	745	4	0	0	1.56
Roncaro	PV	0.39	0.61	14	0.186	0.764	302	81	41.51	31.82	13,580	2.50	36.3	825	5	1	0	-
Rosasco	PV	0.27	0.73	10	0.273	0.722	31	114	13.87	21.99	12,135	2.03	52.7	760	4		0	-
Rovescala	PV	0.24	0.76	11	0.258	0.778	109	250	55.80	27.13	10,841	1.99	49.3	820	4	1	0	
Ruino	PV	0.21	0.79	11	0.184	0.742	35	526	56.84	23.09	10,925	1.84	53.3	745	4	1	0	1.24
San Cipriano Po	PV	0.25	0.75	11	0.228	0.792	57	63	45.95	18.49	10,791	2.28	41.8	825	4	1	0	-
San Damiano al Colle	PV	0.24	0.76	12	0.216	0.754	110	216	54.79	26.18	10,017	2.29	49.9	845	4	1	0	-
San Genesio ed Uniti	PV	0.48	0.52	14	0.184	0.830	425	86	33.89	39.47	17,765	2.36	44.6	1,200	2	1	0	
San Giorgio di Lomellina	PV	0.25	0.75	10	0.180	0.763	43	99	12.34	22.36	12,111	2.09	47.2	785	4	1	0	-
San Martino Siccomario	PV	0.59	0.41	17	0.210	0.799	408	63	33.06	39.54	16,773	2.10	44.3	1,200	2	1	0	1.37
Sannazzaro de' Burgondi	PV	0.39	0.61	9	0.146	0.742	237	87	23.42	28.58	11,146	2.23	46.2	1,005	5	0	0	3.85
Santa Cristina e Bissone	PV	0.34	0.67	12	0.222	0.753	92	71	52.68	18.96	13,240	2.38	44.7	825	4	1	0	-
Santa Giuletta	PV	0.38	0.62	11	0.206	0.771	143	78	43.77	27.71	13,821	2.66	46.9	825	5	1	0	0.24
Sant'Alessio con Vialone	PV	0.24	0.76	11	0.210	0.760	140	83	37.80	26.07	12,914	2.52	37.1	860	3	1	0	-
Santa Margherita di Staffora	PV	0.18	0.82	5	0.402	0.686	14	550	68.74	20.27	13,314	1.62	57.1	705	3	1	0	26.77
Santa Maria della Versa	PV	0.26	0.74	12	0.240	0.764	133	199	53.77	29.77	12,181	2.17	47.4	875	4		0	0.13
Sant'Angelo Lomellina	PV	0.55	0.45	14	0.197	0.806	81	112	9.20	22.02	14,546	2.72	42.9	760	4	1	0	
San Zenone al Po	PV	0.24	0.77	8	0.171	0.721	86	59	51.63	28.45	11,536	2.11	45.7	860	4	0	0	-
Sartirana Lomellina	PV	0.24	0.76	8	0.197	0.765	59	99	19.82	20.56	11,852	2.26	49.2	840	3	0	0	
Scaldasole	PV	0.72	0.28	13	0.273	0.787	82	86	21.38	23.29	12,764	2.41	43.5	875	4	1	0	-
Semiana	PV	0.28	0.72	7	0.162	0.754	24	97	16.19	21.25	11,673	1.97	48.6	840	4	1	0	
Silvano Pietra	PV	0.22	0.78	6	0.174	0.723	50	83	31.06	27.09	12,478	2.31	45.3	745	4	1	0	
Siziano	PV	0.61	0.39	18	0.205	0.825	493	93	35.57	29.77	14,787	2.39	41.3	1,525	4	1	0	
Sommo	PV	0.41	0.60	9	0.221	0.823	80	80	31.10	28.82	14,208	2.35	44.0	895	4	1	0	
Spessa	PV	0.24	0.76	13	0.175	0.783	50	61	50.45	20.95	11,775	2.31	44.5	860	4	1	0	
Stradella	PV	0.28	0.72	15	0.237	0.789	622	101	48.98	34.51	14,097	2.17	46.3	1,065	5	1	1	0.01
Suardi	PV	0.23	0.77	9	0.270	0.715	64	84	27.53	16.3	11,748	2.04	49.6	760	4	1	0	-
Torrazza Coste	PV	0.14	0.86	10	0.225	0.825	107	159	42.82	32.73	13,898	2.37	45.6	840	4	1	0	
Torre d'Arese	PV	0.40	0.60	11	0.218	0.783	227	78	44.55	22.56	12,303	2.51	38.1	860	4	0	0	-
Torre de' Negri	PV	0.33	0.67	10	0.148	0.778	86	73	48.05	15.02	11,151	2.48	47.0	875	4	1	0	-
Torre d'Isola	PV	0.41	0.59	17	0.161	0.861	147	84	26.47	52.68	23,274	2.38	41.5	1,150	3	1	0	-

Torrevecchia Pia	PV	0.53	0.47	17	0.233	0.770	213	84	42.66	25.3	12,656	2.40	38.8	1,500	5	1	1	-
Torricella Verzate	PV	0.24	0.76	12	0.250	0.839	235	160	44.17	34.2	13,907	2.26	47.1	825	5	1	0	-
Travacò Siccomario	PV	0.75	0.25	16	0.240	0.848	295	61	35.29	41.49	17,526	2.27	43.6	955	5	1	0	
Trivolzio	PV	0.55	0.45	19	0.212	0.817	540	97	22.98	33.98	15,378	2.27	41.2	935	4	1	0	-
Tromello	PV	0.32	0.68	12	0.234	0.747	110	97	12.29	22.72	12,594	2.25	44.3	840	3	0	0	
Trovo	PV	0.40	0.60	11	0.228	0.753	130	97	22.27	23.65	12,425	2.63	39.5	935	3	1	0	-
Val di Nizza	PV	0.15	0.85	8	0.325	0.757	22	412	55.48	22.12	12,110	1.80	52.0	815	4	1	0	0.55
Valeggio	PV	0.43	0.57	10	0.206	0.730	25	93	16.95	15.98	10,131	2.22	47.7	760	3	1	0	-
Valle Lomellina	PV	0.35	0.65	12	0.181	0.704	79	101	15.74	18.86	11,585	2.27	46.4	860	3	0	0	
Valle Salimbene	PV	0.52	0.48	11	0.150	0.823	217	71	39.81	27.49	21,715	2.39	44.2	945	4	1	0	-
Valverde	PV	0.26	0.74	8	0.345	0.711	21	567	58.00	23.34	13,179	1.64	55.3	815	4	1	0	2.80
Varzi	PV	0.17	0.83	10	0.241	0.750	58	416	61.81	29.62	13,645	1.99	51.0	825	3	0	0	0.37
Velezzo Lomellina	PV	0.42	0.58	7	0.089	0.727	12	98	13.26	31.76	12,004	2.02	47.3	840	4	1	0	-
Vellezzo Bellini	PV	0.48	0.52	19	0.153	0.804	397	94	27.31	27.65	13,445	2.50	39.8	840	4	0	0	-
Verretto	PV	0.31	0.69	5	0.183	0.798	147	78	39.18	16	11,468	2.49	44.6	780	4	1	0	-
Verrua Po	PV	0.24	0.76	12	0.190	0.766	117	64	38.57	26.39	12,723	2.40	47.5	840	4	1	0	-
Vidigulfo	PV	0.50	0.50	11	0.282	0.773	379	88	38.02	27.31	13,881	2.29	39.5	1,300	2	1	0	-
Vigevano	PV	0.29	0.71	17	0.252	0.746	743	116	9.23	29.09	14,019	2.09	45.2	980	1	0	0	0.41
Villa Biscossi	PV	0.33	0.68	7	0.192	0.871	15	90	21.50	29.85	10,317	2.06	49.8	840	4	1	0	-
Villanova d'Ardenghi	PV	0.57	0.43	13	0.256	0.822	112	86	25.93	20.58	14,715	2.26	46.0	885	4	1	0	-
Villanterio	PV	0.42	0.58	11	0.154	0.771	225	75	48.54	26.21	13,531	2.22	42.9	1,040	4	1	0	
Vistarino	PV	0.40	0.61	11	0.163	0.760	167	72	44.36	23.7	12,326	2.38	40.4	885	5	1	0	-
Voghera	PV	0.24	0.76	16	0.272	0.774	605	96	38.05	36.78	15,262	2.03	47.1	1,250	3	1	0	0.14
Volpara	PV	0.24	0.76	11	0.220	0.784	36	357	56.35	33.9	13,215	1.79	49.8	780	4	1	0	
Zavattarello	PV	0.09	0.91	8	0.284	0.729	36	550	61.31	22.41	12,727	1.82	51.9	780	3	0	0	0.03
Zeccone	PV	0.24	0.76	8	0.150	0.829	313	86	35.34	26.9	14,240	2.51	40.5	1,200	4	1	0	-
Zeme	PV	0.28	0.72	11	0.183	0.755	43	104	11.45	19.96	12,544	2.12	47.4	840	4	1	0	-
Zenevredo	PV	0.24	0.76	12	0.213	0.827	90	204	51.73	30.42	13,027	2.20	46.8	860	5	1	0	
Zerbo	PV	0.39	0.61	9	0.179	0.812	70	68	54.04	18.83	12,110	2.16	49.7	860	4	1	0	-
Zerbolò	PV	0.71	0.29	14	0.202	0.789	45	68	22.16	22.83	13,761	2.17	43.0	945	4	0	0	
Zinasco	PV	0.63	0.37	15	0.193	0.775	110	84	27.75	23.02	13,288	2.25	44.6	885	4	1	0	
Albaredo per San Marco	SO	0.53	0.47	7	0.231	0.613	19	950	50.54	15.32	8,937	2.28	48.8	875	4	1	0	
Albosaggia	SO	0.51	0.49	12	0.233	0.762	92	490	58.69	23.42	14,239	2.25	46.6	1,200	4	1	0	1.34
Andalo Valtellino	SO	0.38	0.62	15	0.254	0.703	83	229	55.08	22.03	12,318	2.32	45.0	950	4	1	0	-
Aprica	SO	0.42	0.58	11	0.259	0.822	77	1172	70.20	31.14	13,273	2.16	43.1	2,175	4	0	0	77.65
Ardenno	SO	0.56	0.44	14	0.204	0.773	191	266	57.35	28.27	12,312	2.41	43.9	1,100	4	0	0	0.98
Bema	SO	0.38	0.62	6	0.337	0.759	6	800	51.15	8.4	12,097	1.64	56.3	875	4	1	0	
Berbenno di Valtellina	SO	0.42	0.58	12	0.210	0.756	120	370	58.68	23.72	11,768	2.51	44.2	1,025	5		0	1.50
Bianzone	SO	0.50	0.50	8	0.255	0.736	74	444	71.56	22.23	10,206	2.36	45.0	1,025	4	1	0	
Bormio	SO	0.53	0.47	17	0.317	0.772	97	1225	108.69	36.63	14,325	2.26	43.7	4,450	4	1	0	103.16
Buglio in Monte	SO	0.40	0.60	7	0.264	0.762	77	577	59.58	18.17	10,873	2.56	43.7	925	5	1	0	
Caiolo	SO	0.49	0.51	12	0.276	0.793	32	335	58.02	25.68	12,294	2.54	48.7	900	4	1	0	
Campodolcino	SO	0.36	0.64	7	0.379	0.785	21	1071	86.21	21.78	10,401	2.15	44.4	2,400	4	0	0	56.56
Castello dell'Acqua	SO	0.35	0.65	6	0.364	0.587	46	664	63.69	13.04	10,734	2.06	47.6	950	4	0	0	-
Castione Andevenno	SO	0.41	0.59	9	0.277	0.738	91	468	60.16	24.22	12,724	2.32	44.7	1,000	4	0	0	
Cercino	SO	0.49	0.51	14	0.270	0.762	123	487	57.10	22.65	10,537	2.33	42.2	950	4	0	0	-
Chiavenna	SO	0.52	0.48	15	0.295	0.756	662	333	76.44	29.64	12,342	2.14	44.8	1,700	3	1	1	4.08
Chiuro	SO	0.61	0.39	14	0.249	0.761	49	390	64.34	26.42	12,302	2.35	45.2	1,075	4	1	0	0.72
Cino	SO	0.45	0.56	13	0.249	0.811	73	504	57.42	13.11	9,343	2.54	41.6	900	4	1	0	
Civo	SO	0.45	0.55	7	0.267	0.722	44	719	56.43	15.62	10,204	2.26	45.0	925	4	0	0	0.13
Colorina	SO	0.34	0.66	9	0.264	0.719	80	302	56.95	20.32	10,651	2.37	43.7	900	3	1	0	-
Cosio Valtellino	SO	0.49	0.51	15	0.294	0.781	227	231	54.20	24.9	12,279	2.44	42.6	1,200	5	1	1	0.98
Dazio	SO	0.39	0.61	6	0.238	0.773	113	568	56.95	25	11,485	1.98	44.5	975	4	0	0	
Delebio	SO	0.48	0.52	12	0.221	0.791	143	218	55.30	30.26	12,240	2.48	42.6	1,025	4	0	0	-
Dubino	SO	0.48	0.52	13	0.219	0.746	277	223	59.67	20.61	10,603	2.64	42.4	1,100	5	1	0	
Faedo Valtellino	SO	0.51	0.49	11	0.331	0.729	117	557	60.73	17.43	11,578	2.22	43.9	925	4	1	0	

Forcola	SO	0.55	0.45	10	0.330	0.771	52	289	56.84	19.61	9,386	2.44	44.2	875	4	1	0	
Fusine	SO	0.63	0.37	10	0.200	0.761	16	285	56.78	22.67	12,320	2.17	46.6	900	4	0	0	-
Gerola Alta	SO	0.41	0.59	7	0.285	0.598	5	1050	45.99	21.33	9,878	1.65	53.0	900	4	1	0	21.48
Gordona	SO	0.52	0.48	14	0.230	0.798	38	283	73.87	21.7	10,930	2.50	41.4	875	4	0	1	0.07
Grosio	SO	0.55	0.45	17	0.240	0.764	36	656	88.79	21.19	10,841	2.50	44.6	1,075	4	0	0	1.82
Grosotto	SO	0.44	0.56	12	0.254	0.745	31	590	86.83	29.78	14,356	2.30	45.3	1,000	4	1	0	
Livigno	SO	0.32	0.68	11	0.331	0.803	29	1816	106.62	23.13	13,534	2.77	44.3	4,600	4	1	0	175.59
Lovero	SO	0.51	0.49	12	0.189	0.788	50	515	80.76	25.09	12,120	2.19	33.9	925	4	0	0	-
Madesimo	SO	0.36	0.64	7	0.398	0.748	6	1399	88.94	31.11	11,763	1.88	44.1	4,700	4		0	138.50
Mantello	SO	0.51	0.49	14	0.233	0.794	202	211	56.67	24.39	12,117	2.51	42.4	925	4	1	0	
Mazzo di Valtellina	SO	0.44	0.56	12	0.282	0.747	67	552	84.50	23.53	12,278	2.40	43.2	950	4	0	0	
Mello	SO	0.44	0.56	9	0.262	0.803	83	681	56.45	9.35	7,235	2.56	40.6	925	4	1	0	
Menarola	SO	0.19	0.81	2	0.429	0.889	3	425	74.67	19.51	10,686	2.35	44.9	800	4	0	0	-
Mese	SO	0.45	0.55	10	0.208	0.803	424	274	75.06	23.53	9,562	2.58	41.7	1,100	4	1	0	
Montagna in Valtellina	SO	0.51	0.49	11	0.234	0.785	63	567	63.25	32.22	14,834	2.25	45.8	1,100	4	1	0	
Morbegno	SO	0.47	0.53	17	0.268	0.787	779	262	54.49	34.28	14,685	2.25	43.9	1,625	5	1	1	0.84
Novate Mezzola	SO	0.56	0.44	14	0.221	0.768	19	212	64.77	22.54	10,539	2.25	43.5	1,050	4	0	0	0.05
Piantedo	SO	0.42	0.58	8	0.218	0.840	202	215	55.60	21.5	11,907	2.51	40.2	950	4	1	0	
Piateda	SO	0.39	0.61	7	0.233	0.755	32	304	62.27	19.75	12,217	2.25	46.6	1,000	4	0	0	-
Piuro	SO	0.81	0.19	16	0.254	0.800	22	382	77.01	21.88	9,034	2.46	42.8	1,000	4	1	0	6.60
Poggiridenti	SO	0.35	0.65	7	0.235	0.779	638	564	63.55	31.24	15,227	2.29	45.1	1,075	4	1	0	1.58
Ponte in Valtellina	SO	0.52	0.48	10	0.230	0.746	33	485	65.23	27.52	13,594	2.22	45.5	1,025	4	1	0	0.10
Postalesio	SO	0.51	0.49	9	0.189	0.736	63	516	59.86	20.23	12,868	2.16	44.6	900	4	1	0	-
Prata Camportaccio	SO	0.50	0.50	11	0.229	0.771	105	352	74.96	22.71	9,335	2.56	40.8	1,100	4		0	
Rasura	SO	0.26	0.74	5	0.381	0.810	53	762	50.38	22.18	9,450	2.36	44.4	875	4	1	0	-
Rogolo	SO	0.49	0.51	13	0.303	0.792	44	216	54.96	23.06	11,710	2.35	41.2	925	4	1	0	-
Samolaco	SO	0.47	0.53	11	0.224	0.792	64	213	67.95	18.63	9,030	2.69	41.3	875	4	0	0	
San Giacomo Filippo	SO	0.32	0.68	9	0.365	0.753	6	522	78.65	12.75	7,716	2.08	47.3	850	4	1	0	
Sernio	SO	0.38	0.62	12	0.283	0.732	51	632	79.06	32.21	11,983	2.30	44.0	1,000	4	1	0	10.55
Sondalo	SO	0.39	0.61	16	0.270	0.719	44	939	93.99	19.64	13,154	2.25	45.6	1,250	5	1	0	2.62
Sondrio	SO	0.47	0.53	18	0.386	0.759	1,054	307	61.31	41.6	16,656	2.11	45.9	1,825	6	0	0	1.36
Talamona	SO	0.49	0.51	14	0.194	0.734	225	285	54.43	21.31	11,180	2.51	42.5	1,050	3	0	0	
Tartano	SO	0.27	0.73	5	0.351	0.636	4	1210	51.13	31.82	10,601	1.72	54.2	875	4	1	0	20.30
Teglio	SO	0.43	0.57	10	0.262	0.679	40	851	68.26	21	11,391	2.16	46.0	1,150	4	1	0	3.23
Tirano	SO	0.41	0.59	15	0.257	0.767	279	441	76.57	34.4	13,177	2.20	45.0	1,500	4	1	0	2.32
Tovo di Sant'Agata	SO	0.43	0.57	12	0.248	0.809	57	526	83.02	24.72	12,598	2.34	42.9	950	4	1	0	
Traona	SO	0.59	0.41	9	0.283	0.793	414	252	56.00	25.31	11,252	2.45	40.1	1,075	3	1	0	
Tresivio	SO	0.49	0.51	9	0.257	0.797	134	504	64.14	30.8	13,772	2.15	44.4	1,100	4	1	0	
Val Masino	SO	0.29	0.71	6	0.246	0.797	8	787	63.00	15.72	8,986	2.25	40.5	975	4	1	0	26.23
Valdidentro	SO	0.39	0.61	12	0.333	0.812	17	1350	107.46	28.09	10,846	2.48	40.6	2,700	4	0	0	32.97
Valdisotto	SO	0.42	0.58	14	0.319	0.756	40	1141	104.90	22.39	11,301	2.54	43.8	2,250	4	1	0	23.40
Valfurva	SO	0.44	0.56	13	0.437	0.727	13	1339	109.99	19.84	10,587	2.58	45.3	2,200	5	0	0	68.60
Verceia	SO	0.55	0.45	10	0.269	0.774	99	200	62.21	16.88	8,852	2.33	42.9	1,000	3		0	
Vervio	SO	0.35	0.65	8	0.288	0.812	17	549	83.26	12.37	10,955	2.03	45.4	950	4	1	0	-
Villa di Chiavenna	SO	0.42	0.58	11	0.280	0.764	32	633	76.39	19.24	6,497	2.40	42.7	900	4	0	0	0.75
Villa di Tirano	SO	0.42	0.58	9	0.258	0.751	120	400	74.03	24.97	11,518	2.33	44.9	950	5	1	0	1.20
Agra	VA	0.72	0.28	16	0.208	0.671	128	655	47.54	43.73	7,866	2.00	48.4	905	4	1	0	-
Albizzate	VA	0.73	0.27	15	0.172	0.792	1,393	334	13.35	29.44	14,682	2.43	43.8	1,040	5	0	0	-
Angera	VA	0.60	0.40	14	0.285	0.796	321	205	26.85	33.41	14,743	2.28	46.2	1,150	5	1	1	2.65
Arcisate	VA	0.67	0.33	17	0.179	0.739	804	381	27.16	22.89	10,629	2.46	42.8	1,025	3	1	0	
Arsago Seprio	VA	0.72	0.28	16	0.205	0.759	470	290	11.91	25.25	13,832	2.35	42.9	940	5	1	0	
Azzate	VA	0.72	0.28	15	0.142	0.789	984	332	19.04	33.3	16,079	2.32	42.7	950	2	0	0	
Azzio	VA	0.65	0.35	19	0.248	0.777	360	399	32.03	30.85	11,937	2.43	42.6	915	4	1	0	
Barasso	VA	0.65	0.35	16	0.176	0.797	425	401	26.24	41.85	18,684	2.31	46.9	1,100	4	1	0	-
Bardello	VA	0.69	0.31	15	0.208	0.792	669	263	27.31	21.31	13,371	2.53	42.6	1,020	5	1	0	-
Bedero Valcuvia	VA	0.51	0.49	10	0.271	0.780	267	520	33.40	37.6	11,635	2.27	43.1	915	4		0	-

Besano	VA	0.59	0.42	13	0.247	0.689	731	350	24.77	20.49	8,200	2.51	42.5	1,025	5	1	0	-
Besnate	VA	0.73	0.27	15	0.211	0.786	723	300	11.13	27.27	14,141	2.40	43.7	975	5	0	1	
Besozzo	VA	0.62	0.38	16	0.250	0.767	666	258	26.96	29.07	12,976	2.36	43.7	1,020	1	1	1	0.14
Biandronno	VA	0.71	0.29	16	0.188	0.804	399	262	24.78	24.9	14,706	2.32	43.9	1,020	2	1	0	-
Bisuschio	VA	0.65	0.35	16	0.217	0.740	610	345	28.86	21.84	9,075	2.41	42.6	1,025	5	1	0	-
Bodio Lomnago	VA	0.73	0.27	15	0.214	0.806	473	273	20.86	40.25	18,566	2.52	44.4	940	1	0	1	
Brebbia	VA	0.64	0.36	16	0.250	0.782	529	225	28.35	24.39	13,049	2.35	45.0	940	5	1	0	1.86
Bregano	VA	0.62	0.38	13	0.270	0.732	366	303	26.63	28.81	12,869	2.45	42.3	1,020	5	1	0	-
Brenta	VA	0.64	0.36	19	0.316	0.736	424	276	33.69	21.51	11,719	2.42	42.6	940	5	1	0	-
Brezzo di Bedero	VA	0.68	0.32	16	0.229	0.739	146	352	41.85	32.79	12,225	2.20	42.4	1,000	4	1	0	
Brinzio	VA	0.64	0.37	19	0.185	0.782	136	510	31.10	32.87	13,552	2.41	44.0	915	4	1	0	
Brissago-Valtravaglia	VA	0.60	0.40	15	0.132	0.676	196	429	38.14	24.85	8,322	2.55	40.9	925	4	1	0	
Brunello	VA	0.73	0.27	15	0.293	0.809	623	411	17.34	33.72	14,650	2.64	41.8	1,020	4	1	1	
Brusimpiano	VA	0.57	0.43	12	0.273	0.703	207	289	31.01	26.06	9,356	2.26	42.5	975	4	1	0	
Buguggiate	VA	0.74	0.26	15	0.156	0.788	1,199	306	19.06	35.74	16,589	2.40	45.1	950	1	1	0	-
Busto Arsizio	VA	0.60	0.40	17	0.276	0.775	2,628	226	-	33.14	15,916	2.21	44.5	1,275	2	1	0	0.26
Cadegliano-Viconago	VA	0.51	0.50	13	0.311	0.621	195	414	32.86	17.18	6,207	2.30	42.1	1,000	4	1	0	
Cadrezzate	VA	0.68	0.32	15	0.274	0.793	371	281	25.91	29.03	12,803	2.40	42.9	975	3	1	0	
Cairate	VA	0.63	0.37	17	0.197	0.776	695	273	8.81	21.82	12,959	2.52	43.0	975	1	0	0	
Cantello	VA	0.65	0.35	18	0.172	0.727	501	404	23.72	26.09	10,169	2.38	43.8	1,025	5	0	0	2.32
Caravate	VA	0.65	0.35	19	0.287	0.734	516	296	32.90	22.63	12,023	2.51	43.5	975	4	1	0	
Cardano al Campo	VA	0.65	0.36	17	0.233	0.782	1,519	240	6.97	27.88	14,790	2.17	42.1	975	5	1	0	11.26
Carnago	VA	0.73	0.27	15	0.169	0.777	1,058	354	12.22	25.33	14,068	2.42	41.9	1,025	5	1	0	-
Caronno Pertusella	VA	0.63	0.38	17	0.285	0.787	1,951	194	14.17	27.97	15,341	2.29	40.8	1,075	6	0	0	
Caronno Varesino	VA	0.63	0.37	14	0.227	0.775	879	403	9.08	23.17	13,856	2.42	43.4	1,025	1	1	1	-
Casale Litta	VA	0.74	0.26	15	0.271	0.771	247	382	18.98	21.57	13,738	2.46	43.3	925	4	0	0	
Casalzuigno	VA	0.61	0.39	19	0.240	0.714	181	350	34.17	25.63	11,096	2.27	44.4	915	4	0	0	
Casciago	VA	0.62	0.38	15	0.299	0.810	967	426	24.89	43.38	18,706	2.50	45.0	1,100	2	0	0	-
Casorate Sempione	VA	0.66	0.34	15	0.154	0.778	843	282	10.08	29.31	14,051	2.35	43.2	975	5	1	1	1.07
Cassano Magnago	VA	0.78	0.22	19	0.277	0.789	1,769	261	6.45	24.97	13,381	2.45	43.6	1,090	2	1	1	
Cassano Valcuvia	VA	0.54	0.46	19	0.291	0.690	163	296	36.04	23.58	10,045	2.29	42.4	880	3	1	0	
Castellanza	VA	0.52	0.48	16	0.258	0.791	2,056	216	4.56	32.76	15,566	2.26	46.3	1,090	1	1	0	0.46
Castello Cabiaglio	VA	0.62	0.38	19	0.328	0.756	78	514	31.97	35.19	14,095	2.17	43.5	905	4	1	0	
Castelseprio	VA	0.68	0.32	12	0.210	0.820	331	310	11.62	26.18	14,958	2.24	44.2	940	5	0	0	-
Castelveccana	VA	0.61	0.39	16	0.235	0.722	95	257	32.28	30.41	12,179	2.09	45.6	1,000	3	1	0	1.06
Castiglione Olona	VA	0.72	0.28	15	0.155	0.756	1,112	307	15.86	24.1	13,667	2.42	43.4	975	2	0	0	
Castronno	VA	0.74	0.26	15	0.147	0.775	1,396	325	15.00	26.95	14,446	2.40	42.7	1,025	1	0	0	0.12
Cavaria con Premezzo	VA	0.73	0.27	15	0.366	0.800	1,774	268	9.56	24.22	13,783	2.48	42.1	1,040	4	0	0	-
Cazzago Brabbia	VA	0.74	0.26	15	0.222	0.779	213	265	22.06	30.83	13,063	2.47	43.6	940	5	1	0	-
Cislago	VA	0.60	0.41	15	0.253	0.805	923	237	11.31	28.46	14,311	2.54	42.1	1,025	5	1	0	
Cittiglio	VA	0.59	0.42	19	0.248	0.728	349	254	34.68	25.72	12,337	2.27	44.4	940	1	1	0	3.02
Clivio	VA	0.63	0.37	16	0.258	0.729	683	468	22.07	20.97	6,152	2.42	42.9	1,025	5	1	0	
Cocquio-Trevisago	VA	0.65	0.35	15	0.241	0.743	496	291	30.29	23.31	12,846	2.35	45.0	940	4	1	0	-
Comabbio	VA	0.57	0.43	13	0.246	0.801	248	307	21.86	33.5	14,656	2.29	42.3	940	5	1	0	
Comerio	VA	0.67	0.33	16	0.216	0.800	467	382	26.82	41.32	18,584	2.23	44.0	1,100	5	0	0	
Cremenaga	VA	0.53	0.47	8	0.260	0.656	169	272	36.64	19.32	4,453	2.88	42.2	905	5	0	0	-
Crosio della Valle	VA	0.74	0.26	15	0.233	0.793	406	322	17.33	25.73	16,400	2.29	43.6	925	5	1	0	-
Cuasso al Monte	VA	0.57	0.43	15	0.259	0.670	221	530	27.69	24.34	9,507	2.18	42.2	835	2	1	0	
Cugliate-Fabiasco	VA	0.67	0.33	15	0.208	0.696	467	516	37.11	20.89	6,158	2.49	40.9	1,000	4	1	0	-
Cunardo	VA	0.67	0.33	15	0.212	0.701	484	450	35.90	24.89	7,897	2.50	41.2	1,000	4	1	0	
Curiglia con Monteviasco	VA	0.70	0.30	15	0.181	0.773	16	670	49.88	12.88	6,787	1.87	49.1	895	4	1	0	1.30
Cuveglio	VA	0.55	0.45	19	0.211	0.709	441	294	33.76	22.9	10,689	2.38	42.3	915	4	0	0	
Cuvio	VA	0.57	0.43	19	0.228	0.720	284	309	32.67	21.02	10,418	2.39	43.4	915	5	1	0	
Daverio	VA	0.73	0.27	15	0.148	0.782	766	327	19.20	30.63	15,144	2.48	42.1	950	5	1	0	
Dumenza	VA	0.64	0.36	17	0.255	0.709	79	411	45.39	21.51	8,293	2.18	45.0	895	4	1	0	
Duno	VA	0.57	0.43	19	0.484	0.764	60	530	34.49	34.4	12,038	1.69	45.6	880	5	1	0	

Fagnano Olona	VA	0.63	0.37	15	0.279	0.782	1,411	265	6.54	23.73	13,603	2.49	42.6	975	2	0	1	
Ferno	VA	0.64	0.36	17	0.246	0.782	820	211	6.84	22.2	12,702	2.52	42.2	975	2	1	0	
Ferrera di Varese	VA	0.65	0.35	19	0.176	0.714	469	299	35.85	16.45	7,749	2.37	40.8	905	4	1	0	-
Gallarate	VA	0.65	0.35	16	0.297	0.778	2,430	238	7.00	37.42	16,048	2.19	43.5	1,100	6	0	0	0.66
Galliate Lombardo	VA	0.74	0.26	15	0.249	0.839	270	335	19.98	42.71	28,060	2.48	41.6	940	4	1	0	-
Gavirate	VA	0.65	0.35	16	0.216	0.786	688	261	27.06	34.57	15,211	2.30	45.3	1,100	2	1	0	2.48
Gazzada Schianno	VA	0.72	0.28	15	0.174	0.792	975	368	18.53	29.7	15,109	2.28	44.6	1,025	1	0	0	2.75
Gemonio	VA	0.63	0.37	14	0.182	0.755	778	303	32.11	30.39	12,579	2.38	42.6	940	3	1	0	
Gerenzano	VA	0.67	0.33	15	0.238	0.790	1,096	226	12.71	32.21	15,514	2.38	41.4	1,025	1	1	0	
Germignaga	VA	0.61	0.39	16	0.186	0.708	616	204	43.12	25.89	9,810	2.18	43.8	1,090	4	1	0	
Golasecca	VA	0.66	0.34	15	0.253	0.729	356	280	16.60	23.91	14,365	2.20	44.3	925	4	1	0	
Gorla Maggiore	VA	0.53	0.47	15	0.135	0.805	949	258	-	24.46	14,318	2.47	43.5	975	4	1	0	
Gorla Minore	VA	0.52	0.48	15	0.231	0.787	1,090	237	2.86	26.55	14,012	2.40	42.4	975	5	1	0	
Gornate-Olona	VA	0.60	0.41	9	0.281	0.803	468	303	8.77	26.19	13,944	2.52	41.9	905	2	1	0	
Grantola	VA	0.60	0.41	15	0.134	0.689	614	250	37.83	18.99	7,514	2.48	40.8	975	4	1	0	
Inarzo	VA	0.74	0.26	15	0.236	0.806	451	261	21.01	28.72	14,563	2.54	41.7	940	4	0	0	-
Induno Olona	VA	0.65	0.35	17	0.176	0.738	835	394	26.23	30.1	13,488	2.40	43.6	1,100	5	1	0	
Ispra	VA	0.71	0.30	16	0.176	0.787	329	220	28.74	34.67	12,402	2.27	44.6	1,090	5	1	0	3.56
Jerago con Orago	VA	0.73	0.27	15	0.148	0.801	1,276	324	10.90	28.3	14,658	2.47	42.8	1,040	3		1	
Lavena Ponte Tresa	VA	0.52	0.48	15	0.223	0.681	1,252	275	32.68	22.3	6,248	2.24	43.3	1,090	4	1	0	5.93
Laveno-Mombello	VA	0.62	0.39	16	0.256	0.739	344	205	36.81	30.15	13,756	2.18	47.8	1,350	2	0	0	1.30
Leggiuno	VA	0.70	0.30	16	0.200	0.761	275	240	33.98	28.94	13,149	2.27	43.5	975	4	1	0	1.29
Lonate Ceppino	VA	0.64	0.36	14	0.216	0.795	1,035	287	10.66	23.58	13,366	2.48	41.3	905	1	1	0	-
Lonate Pozzolo	VA	0.55	0.45	17	0.241	0.775	404	205	7.05	23.21	13,103	2.48	42.7	975	3	1	0	3.70
Lozza	VA	0.74	0.26	15	0.209	0.828	752	329	18.20	25.94	14,268	2.40	41.7	940	5	1	0	
Luino	VA	0.54	0.46	16	0.275	0.688	680	202	43.83	34.84	10,185	2.11	45.6	1,275	4	0	0	2.37
Luvinate	VA	0.68	0.32	17	0.253	0.809	308	425	25.85	49.3	20,764	2.36	45.4	1,100	4	1	0	
Maccagno	VA	0.62	0.38	12	0.246	0.713	119	210	48.62	30.06	10,489	2.02	47.0	1,000	4	1	0	23.36
Malgesso	VA	0.63	0.37	13	0.261	0.742	472	291	27.22	21.12	12,377	2.46	42.5	940	2	0	0	-
Malnate	VA	0.58	0.42	18	0.252	0.742	1,912	355	13.92	28.17	11,845	2.41	42.8	1,125	6	0	1	
Marchirolo	VA	0.47	0.53	14	0.281	0.642	623	500	37.29	22.11	6,478	2.43	40.9	915	4	1	0	
Marnate	VA	0.61	0.39	17	0.264	0.797	1,556	227	5.46	26.07	15,184	2.40	42.3	975	2	1	0	-
Marzio	VA	0.46	0.54	6	0.389	0.749	160	728	30.38	30.4	9,326	2.15	44.4	905	4		0	
Masciago Primo	VA	0.52	0.49	19	0.224	0.763	155	343	34.28	33.98	11,562	2.50	42.9	880	4		0	
Mercallo	VA	0.65	0.35	15	0.198	0.801	345	277	20.30	24.26	13,938	2.25	43.3	940	5	1	0	
Mesenzana	VA	0.60	0.40	16	0.169	0.678	299	305	38.22	22.91	8,030	2.37	40.6	975	4	1	0	-
Montegrino Valtravaglia	VA	0.59	0.41	15	0.179	0.678	140	525	40.60	23.28	9,855	2.18	43.2	895	4	0	0	
Monvalle	VA	0.67	0.33	14	0.219	0.797	479	226	31.82	31.51	12,952	2.26	42.5	1,090	5	0	0	4.68
Morazzone	VA	0.72	0.28	15	0.155	0.794	782	432	16.96	25.7	14,117	2.50	43.9	1,025	1	0	0	
Mornago	VA	0.74	0.26	15	0.216	0.769	399	281	16.47	25.53	14,691	2.51	41.8	925	2	1	0	
Oggiona con Santo Stefano	VA	0.73	0.27	15	0.202	0.799	1,582	284	10.39	25.12	13,524	2.55	42.8	1,020	5	1	0	-
Olgiate Olona	VA	0.64	0.37	15	0.271	0.816	1,686	239	3.18	30.76	15,701	2.43	43.0	935	3	1	0	4.59
Origgio	VA	0.59	0.41	17	0.353	0.823	934	194	12.45	28.04	16,586	2.31	43.0	1,025	2	1	0	-
Orino	VA	0.58	0.42	19	0.265	0.734	214	456	31.47	34.49	13,128	2.11	44.9	915	4	0	0	
Osmate	VA	0.68	0.32	13	0.159	0.778	231	333	24.20	39.63	13,610	2.26	39.8	1,020	4	1	0	-
Pino s/s Lago Maggiore	VA	0.70	0.30	12	0.172	0.644	31	289	54.92	26.51	6,860	2.00	45.9	895	4		0	-
Porto Ceresio	VA	0.57	0.43	12	0.236	0.715	589	280	32.58	26.44	7,898	2.16	44.3	1,090	4	1	0	
Porto Valtravaglia	VA	0.63	0.37	16	0.228	0.692	146	199	40.55	28.85	11,753	2.14	46.8	1,000	4	0	0	1.82
Rancio Valcuvia	VA	0.59	0.41	19	0.194	0.686	205	296	34.16	19.6	9,473	2.29	42.0	915	4		0	-
Ranco	VA	0.72	0.28	13	0.159	0.772	209	214	29.52	42.12	15,291	2.18	43.6	1,090	5	1	0	11.86
Saltrio	VA	0.51	0.49	14	0.225	0.698	875	543	29.30	18.71	6,570	2.42	43.5	1,025	4	1	0	
Samarate	VA	0.67	0.33	18	0.225	0.791	1,011	221	4.80	26.72	13,660	2.45	44.2	975	2	0	0	
Sangiano	VA	0.66	0.34	13	0.217	0.721	699	223	33.42	24.76	11,880	2.41	43.0	975	4	1	0	-
Saronno	VA	0.70	0.30	16	0.231	0.799	3,589	212	11.87	41.68	17,833	2.21	44.9	1,425	6	1	0	4.77
Sesto Calende	VA	0.64	0.36	18	0.230	0.789	459	198	19.81	35.55	15,847	2.21	44.5	1,090	2	0	0	4.12
Solbiate Arno	VA	0.72	0.28	15	0.186	0.794	1,424	325	12.39	29.17	15,157	2.43	42.7	1,020	5	1	1	

Solbiate Olona	VA	0.61	0.40	16	0.262	0.789	1,138	247	8.68	25.46	13,924	2.49	42.8	975	5	0	0	
Somma Lombardo	VA	0.62	0.38	18	0.237	0.756	567	282	13.05	27.56	14,218	2.29	43.7	1,030	2	1	0	15.61
Sumirago	VA	0.66	0.34	17	0.248	0.773	540	392	11.71	25.09	15,005	2.49	43.8	975	1	1	0	
Taino	VA	0.69	0.31	14	0.207	0.792	485	262	24.31	36.96	15,192	2.33	43.7	940	4	1	0	
Ternate	VA	0.66	0.34	16	0.360	0.778	499	281	22.14	23.27	14,784	2.32	43.7	1,020	4	1	0	5.52
Tradate	VA	0.73	0.27	17	0.300	0.774	863	303	5.14	33.04	14,993	2.31	43.7	1,065	1	1	1	1.13
Travedona-Monate	VA	0.71	0.29	16	0.184	0.779	445	273	25.11	31.4	14,469	2.33	43.2	1,020	2	0	0	
Tronzano Lago Maggiore	VA	0.64	0.36	13	0.286	0.633	23	342	53.78	21.66	6,376	1.98	46.8	895	4	1	0	
Uboldo	VA	0.60	0.40	15	0.235	0.793	986	205	10.38	27.84	15,017	2.34	42.3	1,025	4	1	0	-
Valganna	VA	0.45	0.55	7	0.297	0.718	127	460	26.82	27.09	9,643	2.22	43.2	1,000	4	1	0	
Varano Borghi	VA	0.67	0.33	15	0.172	0.773	740	281	20.97	26.93	14,408	2.23	44.5	1,020	5	1	0	
Varese	VA	0.58	0.42	22	0.397	0.740	1,444	382	24.14	42.2	16,982	2.19	45.9	1,675	2	1	1	2.88
Vedano Olona	VA	0.72	0.28	15	0.213	0.776	1,022	360	18.50	29.48	13,239	2.43	44.3	975	2	0	0	
Veddasca	VA	0.64	0.36	10	0.262	0.496	14	896	51.08	17.72	8,940	1.44	57.4	895	4	0	0	
Venegono Inferiore	VA	0.58	0.42	17	0.205	0.787	1,073	320	7.92	30.36	14,081	2.45	43.2	1,025	5	1	1	-
Venegono Superiore	VA	0.62	0.38	16	0.204	0.771	1,049	331	9.83	32.47	13,988	2.41	43.2	1,040	2	0	1	
Vergiate	VA	0.70	0.30	19	0.212	0.770	413	270	16.70	27.56	14,360	2.35	44.5	1,025	4	0	0	7.48
Viggiù	VA	0.58	0.42	17	0.246	0.688	562	482	22.93	20.54	7,882	2.43	43.9	1,025	1	0	0	
Vizzola Ticino	VA	0.67	0.33	9	0.274	0.793	76	196	12.38	35.42	19,961	1.89	43.1	860	4	0	0	

Analytical Summary