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Inter-municipal cooperation in drinking water supply: Trade-offs between transaction costs, efficiency and service quality

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Abstract

Inter-municipal cooperation (IMC) is frequently promoted as a solution to improve the management of local utilities such as drinking water. Yet its effectiveness remains ambiguous: while IMC can create economies of scale, it may also induce transaction costs that undermine its benefits. In France, drinking water services are managed at the municipal level, where local governments can decide whether to cooperate—and if so, whether to adopt a purely technical cooperative arrangement or a more politically integrated, supra-municipal governance structure. Using a comprehensive panel of French water utilities from 2008 to 2021, we investigate the factors that lead municipalities to remain independent. Our econometric analysis, based on a correlated random effects probit model with a control function approach, yields several key findings. First, while IMC is associated with higher water prices, these increased tariffs are offset by better network performance, as indicated by lower water loss indices and improved water quality. Second, we find that the more politically integrated form of cooperation is more common among publicly managed utilities and among municipalities seeking to reduce their dependence on imported water. These findings provide new insights into the governance of common-pool resources, suggesting that while cooperation can improve service provision, its institutional design must carefully balance organizational costs against expected efficiency gains.

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1 Introduction

Drinking water management is emerging as one of the most critical challenges of the 21st century, exacerbated by climate change, pollution, over-exploitation of resources, and aging infrastructure. The Intergovernmental Panel on Climate Change (IPCC) warns that if temperatures rise by more than 3°C, over 170 million people could face severe drought, undermining both food and water security. The recent droughts in Europe in 2022 and 2023 serve as a stark reminder that even developed countries are vulnerable to prolonged water scarcity.

While inter-municipal cooperation (IMC) is frequently suggested as a solution to the challenges of sustainable water management, its effectiveness remains mixed. Drawing on Ostrom's theory of common pool resources, water is viewed as a common good that demands robust institutional frameworks to balance efficiency, equity, and sustainability (Ostrom, 1990). As water resource management has become a central concern in public policy and academic research, many countries—including France—have decentralized water management to local government levels; however, fostering cooperation among these entities is essential to avoid issues such as free-riding or monopolization.

In the literature, IMC is defined as "*the cooperation of two or more neighbouring or non-neighbouring local governments in the provision of one or more public utilities within their respective jurisdictions*" (Bel and Elston, 2023). Given the high fixed costs inherent in water services, pooling resources allows municipalities to reduce the duplication of public utilities (Elston et al., 2018; Zeemering, 2019), making IMC the theoretically optimal governance model. Yet, such cooperation can also generate additional transaction costs through extra negotiations, increased political interference, and heightened complexity (Bel and Warner, 2015). While the effects of IMC on public utility performance are well documented (Bel and Warner, 2015; Guelmamen, 2025), there is far less consensus on its determinants; some studies suggest that municipalities focus solely on reducing production costs when deciding to cooperate, whereas others point to spatial, fiscal, and organizational factors (Bel and Warner, 2016). Notably, little research has examined the drinking water sector or the determinants that lead a municipality to prefer one form of cooperation over another.

France provides a particularly compelling context for studying IMC in drinking water management due to its highly fragmented institutional landscape. With roughly 12,000 water services—90% serving populations under 10,000—and over 70% managed by individual municipalities acting independently, there is substantial heterogeneity in governance arrangements. Among those municipalities that voluntarily choose to cooperate (cooperation is not mandatory), two institutional forms prevail: the syndicate, a historical, technically oriented, and apolitical arrangement; and the community, an autonomous political entity with its own elected officials, established in 1999 to streamline local governance. Moreover, local governments can decide whether to privatize or publicly provide water.

These observations prompt two central research questions. First, what are the determinants and effects of inter-municipal cooperation in the drinking water sector? Second, do the institutional arrangements of IMC influence both the decision to cooperate and the performance of water services? We contend that, beyond traditional economic considerations, structural and contextual factors—such as the condition of the water network, water quality, and inter-service relationships—play a decisive role. Furthermore, the political and organizational transaction costs associated with different forms of cooperation may critically the overall effectiveness of IMC.

Using an extensive panel dataset of over 10,000 water services from 2008 to 2021, we estimate the probability of IMC using a binary probit model, followed by a multinomial probit model to distinguish between two types of IMC: communities and syndicates. To address two types of endogeneity arising from unobserved individual heterogeneity and time-varying unobservables, we combine the correlated random effects (CRE) and control function (CF) approaches developed by Wooldridge (2015, 2019) and Lin and Wooldridge (2019).

Our results reveal three key findings. First, IMC does not necessarily lead to lower water prices; on the contrary, water prices are often higher under IMC, reflecting additional transaction costs and the financing of investments enabled or encouraged by cooperative arrangements. Second, water services under direct public management are more inclined to cooperate than those delegated to private operators, primarily because lower transaction costs—stemming from reduced contractual and legal constraints—influence both the decision to cooperate and the form of cooperation chosen (syndicate versus community). Third, while IMC generally improves network performance—as evidenced by lower loss rates—the quality improvements are more pronounced in some institutional forms (e.g., communities rather than syndicates). Consequently, cooperation tends to attract services facing resource constraints, such as those relying on water imports, even though it does not necessarily reduce such dependence structurally.

The major contribution of this article is to enrich the debate on the trade-offs between reduced production costs achieved through pooling resources and increased transaction costs—particularly political and organizational ones—generated by the institutional arrangements that structure cooperation. This debate is crucial for public policymakers as they question the future governance of local commons.

The structure of the article is as follows: Section 2 presents our literature review, followed by Section 3, which describes the institutional details of the French water market and the IMC process. Section 4 presents our comprehensive panel dataset of French water services. We then describe the empirical strategy in section 5. Section 6 presents the results of our estimations. Finally, we discuss our results and conclude in Section 7.

2 Literature review and research hypotheses

This section reviews the existing literature on the effects of IMC and specifically addresses unique considerations on the water sector. Our aim is to summarise the body of research in order to understand the determinants and implications of IMC, particularly in the context of public utility provision in the water sector.

2.1 Cost rationalisation

The literature identifies numerous potential benefits of IMC, particularly in the context of local natural monopolies. In Ostrom's seminal work (Ostrom et al., 1961), collective management is portrayed as an effective way to manage natural resources, including drinking water. More specifically, Bel and Warner (2015) argue that aggregating demand across multiple municipalities can lead to lower costs and prices, through shared fixed costs, a prediction that is well supported by standard industrial organization theory and is especially relevant for natural monopolies characterized by substantial fixed costs (Elston et al., 2018; Zeemering, 2019). Economies of scale imply that as the size of an operation increases, average costs decline due to the spreading of fixed costs over larger outputs and reductions in variable costs driven by standardization and learning (Baumol et al., 1982). Local public utilities that operate extensive networks, such as those in transport, gas, water, and waste management, provide a strong case for the benefits of IMC. Subsequent studies have further emphasized that economies of scale improve efficiency and reduce costs in these sectors (Garcia and Thomas, 2001; Garcia, 2003; Guengant and Leprince, 2006; Bel and Fageda, 2009; Lago-Peñas and Martinez-Vazquez, 2013). For water services, shared investments in infrastructure—such as treatment plants, pipelines, and centralized administrative functions—illustrate the potential gains from IMC.[1] Overall, IMC is seen as a mechanism to enhance the economic performance of the French drinking water sector.

Hypothesis 1: IMC, through economies of scale, is associated with lower average costs and prices.

Further arguments in favour of IMC can be made. Within the new institutional economics (NIE) vein of Coase (1937) and Williamson (1976), IMC can be analysed, depending on the level of integration, as a potential source of economies of scale in transaction costs. In particular, increasing the size of the market makes it possible to decrease the number of transactions (e.g., outsourcing contracts in the case of municipalities) and thus enables local governments to reduce costs. From this perspective, the NIE framework is particularly well suited to address these issues, especially where the potential for production economies of scale is limited, such as in cases where network interconnection is not feasible.

Moreover, other strands of literature can be leveraged to suggest that IMC might enhance contractualisation, and thereby reduce opportunistic behaviours by stakeholders (through malicious renegotiation) or third parties (Moszoro and Spiller, 2011) who might

[1] Similarly, economies of scope—cost savings achieved by jointly producing multiple outputs (e.g., water supply, wastewater treatment, and infrastructure maintenance)—are also relevant.

exploit loopholes in poorly drafted contracts due to small municipalities' lack of expertise. In addition, larger and more cooperative structures are likely to have a greater capacity to effectively monitor their services (Deller and Rudnicki, 1992; Zafra-Gómez et al., 2014), thus influencing contracting and the distribution of contract revenues (Levin and Tadelis, 2010; Hefetz and Warner, 2012; Bel et al., 2010). Therefore, the decision to cooperate should be influenced by both the nature of contractual agreements and the sharing of potential resulting financial benefits.

An inter-municipal structure can thus be seen as an institutional form composed of members with common objectives. Some of these objectives diverge due to different ideologies (Bel et al., 2023) and Bel and Warner (2015) have highlighted that IMC can have ambivalent effects. Although it has the theoretical potential to promote economies of scale, it can also increase coordination and transaction costs due to the need for more extensive management of the political interface (Feiock, 2007). Some authors like Rodrigues et al. (2012) even refer to "political transaction costs". Here again, the NIE literature can be cited to demonstrate that conversely, if IMC generates complexity, it could have the opposite effect by increasing transaction costs, as shown by Mayol and Saussier (2023).

As Bel and Warner (2015) have shown, the way in which inter-municipal cooperation is organized can generate political transaction costs that diminish the benefits of cooperation. Following this line of thought, we believe it is important to emphasize that organizational costs can affect both the incentive to join an inter-municipal cooperation arrangement and the form chosen to structure it. This original application of the transaction-cost perspective proposed by Williamson (1976) in the public sector allows us to extend the analysis to include the organizational costs of cooperation. Accordingly, we can formulate the following hypothesis:

Hypothesis 2: The more political the form of IMC, the higher the associated political transaction costs, thereby reducing the benefits of cooperation.

2.2 Privatisation, remunicipalization and cooperation

Numerous studies have assessed management performance in the water sector, focusing on management modes since the late 1990s and early 2000s. Estimating water prices in France is challenging because it is difficult to ascertain counterfactual prices under alternative management regimes. Some studies employing endogenous switching regression models have been able to disentangle the price margins associated with delegated management from those reflecting the inherent complexity of service operations. These findings suggest that the higher prices observed under private delegation are not solely due to profit margins; rather, they also reflect the costs associated with managing more complex service conditions. This phenomenon would similarly affect publicly managed services under comparable circumstances (Carpentier et al., 2006). Similarly, Boyer and Garcia (2008) find that municipalities delegate water service operations when doing so yields lower costs due to higher productive efficiency, although services under direct public management may perform better in terms of network returns.

Chong et al. (2015) offer an additional perspective, arguing that higher prices under delegated management—often associated with the overpricing of smaller services—prompt small municipalities to pursue IMC as a means to increase their bargaining power and regain control over public utilities. Public service delegations inherently generate transaction costs, as government-private operator agreements must be more comprehensive to account for non-contractible investments, especially those involving human capital (Chong et al., 2006). Renegotiations further add to these costs, particularly when opportunism by third parties is a concern (Beuve et al., 2019). Consequently, water services under direct public management are more inclined to cooperate than those delegating resource management to private companies.

Hypothesis 3: A publicly managed water service is more likely to cooperate than one delegated to a private operator.

2.3 Improving service quality

IMC is frequently promoted as a means to improve the quality of water services by pooling technical expertise and resources between municipalities. The industrial organization literature underscores the importance of technical efficiencies achieved via joint operations (Laffont and Tirole, 1993). For instance, shared access to advanced treatment technologies and skilled labor can improve water treatment, flow volume, and domestic supply pressure, as evidenced in studies on water utility performance (Zafra-Gómez et al., 2020). Moreover, IMC can mitigate asymmetric information problems—as smaller municipalities often lack the technical capacity to monitor and manage water quality effectively—by facilitating knowledge sharing and fostering best practices, thereby reducing moral hazard and enhancing overall performance (Macho-Stadler and Pérez-Castrillo, 1993). However, the empirical literature also documents a trade-off: quality improvements under IMC are frequently accompanied by higher water prices, reflecting the increased costs of meeting stringent quality standards and the redistribution of financial burdens among cooperating municipalities.

Hypothesis 4: IMC improves the quality and performance of water services, including drinking water quality and network efficiency, but leads to higher water prices.

2.4 Strengthening water resource management

Effective water resource management is another key objective of IMC, particularly amid the growing challenges of climate change and resource scarcity. The literature emphasizes the importance of collective action in managing common pool resources such as water (Ostrom, 1990). By promoting coordination among communities, IMC enables more sustainable water abstraction, allocation, and conservation, and allows for coordinated planning and investment in infrastructure—such as shared reservoirs and treatment plants—that optimizes resource use over a larger geographic area and reduces inefficiencies associated with fragmented management. IMC can be particularly attractive for water-importing services that face resource shortages, as cooperative structures offer a strategic means to address these constraints by leveraging shared infrastructure and technical expertise. Conversely, water-exporting services, which are more self-sufficient, may have fewer immediate incentives to cooperate, although they might still view IMC as a revenue-generating opportunity through the sale of surplus water under favorable conditions. Ultimately, the relative strength of these competing forces remains ambiguous, reflecting the complex interplay of motivations behind IMC in water services.

Hypothesis 5: IMC integrates the issue of scarcity of raw water resources, reducing dependence on external water imports.

Finally, Table 1 summarises our key hypotheses.

Table 1: Summary of research hypotheses, supporting references, and justifications

Hypothesis	**Key References**	**Justification**
H1: *IMC, through economies of scale, is associated with lower average costs and prices.*	Ostrom et al. (1961), Bel and Warner (2015), Elston et al. (2018), Zeemering (2019)	Pooling resources allows fixed costs to be shared between municipalities, reducing average costs in sectors characterised by high fixed costs.
H2: *The more political the form of IMC, the higher the associated political transaction costs, thereby reducing the benefits of cooperation.*	Coase (1937), Williamson (1976), Bel and Warner (2015), Feiock (2007), Rodrigues et al. (2012), Mayol and Saussier (2023)	The increased complexity of managing political interfaces in politicised forms of IMC increases transaction costs, potentially offsetting the gains from economies of scale.
H3: *A publicly managed water service is more likely to cooperate than one delegated to a private operator.*	Carpentier et al. (2006), Boyer and Garcia (2008), Chong et al. (2015), Chong et al. (2006), Beuve et al. (2019)	Public management involves lower transaction costs and fewer contractual constraints, making cooperation a more attractive option than private delegation.
H4: *IMC improves the quality and performance of water services (e.g., drinking water quality and network efficiency), but leads to higher water prices.*	Laffont and Tirole (1993), Zafra-Gómez et al. (2020), Macho-Stadler and Pérez-Castrillo (1993)	While cooperative arrangements facilitate access to advanced technologies and knowledge sharing, and thereby improves service quality, they also incur higher costs, which are passed on in the form of higher prices.
H5: *IMC addresses the scarcity of raw water resources by reducing dependence on external water imports.*	Ostrom (1990)	Coordinated resource management through IMC enables more sustainable planning and infrastructure investment, reducing reliance on external water sources.

3 Institutional Framework of the French Drinking Water Sector

Since the 1789 French Revolution, 36,000 municipalities in France have been responsible for providing drinking water and treating wastewater. This local management is driven in part by the technical challenge of maintaining water quality over long distances – the farther water must travel, the greater the risk of degradation – and by the fact that water services operate as natural monopolies due to the high costs of duplicating distribution networks. With fixed costs representing between 80% and 95% of total expenditures, local management is economically justified.

Nonetheless, recognizing the burden of such high fixed costs, the French government quickly facilitated IMC for municipalities willing to collaborate. In 1890, the government created *syndicates* to coordinate technical matters—such as water, transportation, and waste management—across municipalities. Syndicates are freely established by municipalities, with boundaries that are not restricted to administrative borders. For example, municipalities can jointly manage a single water source regardless of their individual limits. These structures operate on budgets contributed by member municipalities, yet lack the authority to levy taxes directly, and their associative nature makes exiting relatively straightforward.

In 1999, as part of a broader effort to rationalize local governance, the government introduced a new form of IMC known as *communities*. Unlike syndicates, communities are autonomous, permanent political entities with their own elected officials and fiscal autonomy, designed to streamline local governance and, in principle, to promote municipal mergers. However, in the drinking water sector, communities remain a minority form.

Today, more than 60% of water services in France continue to be managed by individual municipalities that opt not to cooperate. Administrative reports and studies (e.g., Chong et al. (2015)) have long criticized this fragmentation. Figure 1 shows that 85% of French water services serve fewer than 10,000 inhabitants, underscoring the small scale at which many services operate. In response to these challenges, voluntary consolidations have slowly increased, and recent data (Figure 2) indicate a rising proportion of water services managed by communities relative to syndicates, suggesting that even modest incentives have begun to affect local consolidation decisions.

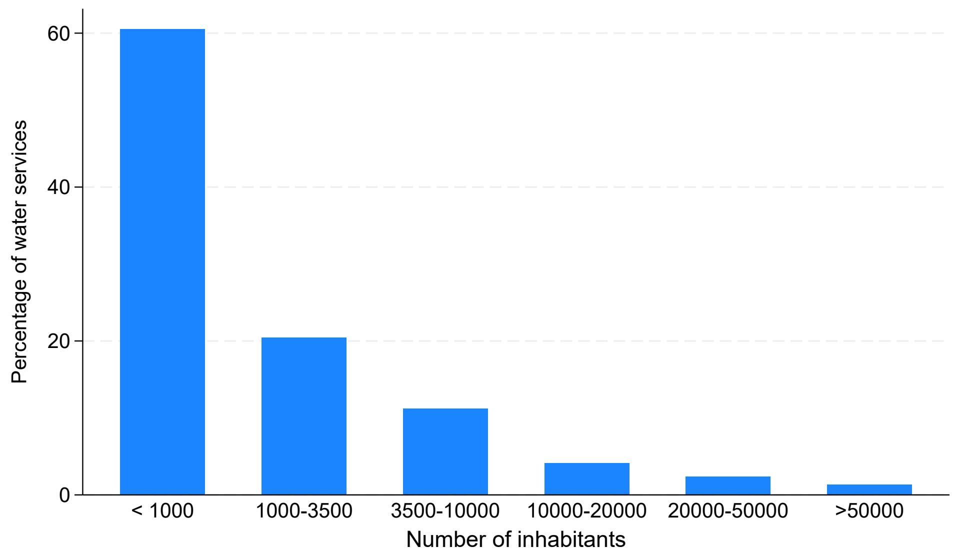

Figure 1: Distribution of Water Services by Number of Inhabitants Served

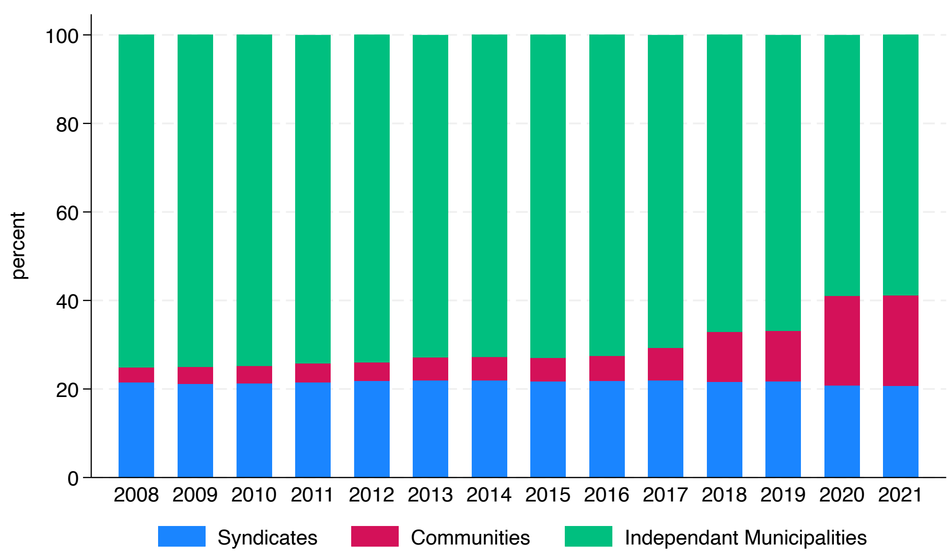

Figure 2: Dynamics of Institutional Arrangements for Water Services

In summary, while drinking water management remains by default a municipal competence, local authorities may choose to cooperate via either a syndicate or a community, and they can also decide between public management and private provision of water services. Moreover, the pricing of drinking water in France is determined under the principle that "water pays for water." The final tariff must cover all costs—both fixed (e.g., infrastructure, treatment facilities, reservoirs, pipelines) and variable (e.g., water treatment, pumping, energy, maintenance). Although taxes and fees imposed by the state agencies -named *Agences de l'Eau*- are added to the base price, the primary pricing decision is made by the local political authority. Consequently, the tax net price is expected to reflect local cost evolution accurately in the absence of a national price regulator.

4 Data and sample

Our analysis was conducted using data from the French Biodiversity Office (FBO), which collects annual data on all French water services.[2] It is important to note that our database is not at the scale of the municipality but rather at the scale of the water service, which can be a municipality or an inter-municipal structure. The dataset provides financial, organizational, institutional, and contractual information. The annual data, including indicators and variables, are provided by the local authorities and verified by the department. We collected data on the 13,000 French water services from 2008 to 2021, resulting in a comprehensive panel dataset of more than 177,000 observations. Our sample includes all sizes of water services. We eliminated water services with missing information on prices and the identity of the water operator.
The variables used in our models are described in Table 2.

4.1 Dependent variables

Firstly, the Price variable refers to the price paid by consumers for 120m^3 of water. This price is set by the public authorities and depends on various factors such as the quality of the water resource, geographical conditions, population density, the level of service chosen, the policy for renewing the service, the investments made and how they are financed. This price also includes resource conservation and pollution charges levied by the water authority. In addition, the tariff includes value-added tax (VAT). We measure this price in € adjusted for inflation.[3] The Price variable does not include the sanitation

[2]The dataset is open access and available here : http://www.services.eaufrance.fr/donnees

[3]The data used to adjust the price for inflation were provided by the French National Institute for Statistics and Economic Studies.

Table 2: Description of Variables

Variables	Description
Dependent variables	
Price (2015 constant €)	Prices paid by consumers for 120 cubic meters of drinking water
IMC	= 1 if the service is managed by an inter-municipal structure, 0 if it is managed by a municipality
Municipality	= 1 if the service is managed by a municipality, 0 otherwise
Community	= 1 if a community is responsible for the water provision, 0 otherwise
Syndicate	= 1 if a syndicate is responsible for the water provision, 0 otherwise
IMC type	= 0 if the service is managed by a municipality, 1 managed by a community and 2 managed by a syndicate
Independent variables	
Public	= 1 if the service is under direct public management, 0 otherwise
Loss index (m^3/km/day)	Ratio of distribution losses to pipe length per day
Microbio Quality (%)	Water compliance rate for microbiological parameters
Physico Quality (%)	Water compliance rate for physico-chemical parameters such as pesticides, nitrates, chromium and bromate
Import share (%)	Proportion of produced water imported
Export share (%)	Proportion of produced water exported
Population	Number of inhabitants served by a water service
Produced volume (billions of m^3)	Total volume produced
Imported volume (billions of m^3)	Total volume imported
Exported volume (billions of m^3)	Total volume exported
Municipalities	Number of municipalities in a water service
Length of network (km)	Total length of pipes used to distribute drinking water
Taxes (2015 constant €)	Total amount of taxes and fees

portion. Second, we constructed several variables related to IMC. The Cooperation variable is a binary variable equal to 1 if the water provision is under the responsibility of an inter-municipal structure, and 0 otherwise. We also constructed the Municipality variable, which is equal to 1 if the water service is managed by a municipality, and 0 otherwise. We constructed variables related to the different forms of cooperation: Syndicate which takes the value 1 if the service is managed by a syndicate, 0 otherwise, and Community which takes the value 1 if the service is managed by a community.

4.2 Independent variables

Provision

Previous studies have shown that the type of provision significantly affects water prices (Carpentier et al., 2006; Boyer and Garcia, 2008; Chong et al., 2015). To capture this effect, we include a Public variable in our empirical strategy that distinguishes between public direct management and private delegated management. This variable is coded as 1 for services managed directly by public authorities and 0 for those delegated to private operators. By including this variable, we aim to assess its effect on both the level of water prices and the likelihood of IMC.

Infrastructure quality

The dataset provides information on leaks in the water infrastructure. The variable Loss index measures losses due to leakage in the distribution network. This variable is a proxy for the quality and the environmental performance of the network. It is important to note that the quality of the network has been regulated since the law of 27 January 2012. This regulation imposes penalties on services that do not meet a minimum return rate.

Water quality

The European Union (EU) imposes strict standards on the quality of drinking water supplied by local authorities or private companies. Two major European Commission directives address the quality of drinking water intended for human consumption (15 July 1980 and 3 November 1998). A third directive (22 October 2013) requires new standards for the protection of public health with regard to radioactive substances in water intended for human consumption. In order to increase transparency for consumers, water services are required to produce an annual report on the quality and price of drinking water. In the case of public service delegation, the delegate must produce an activity report, including financial statements relating to the management of drinking water and an analysis of the quality of service. Water must meet around 70 criteria to be considered drinking water, and the database provided by the FBO contains extensive information on the quality of this resource. It is crucial to include resource quality in our study, as Destandau and Garcia (2014) has shown that excluding it leads to biased estimates. Microbio quality is an indicator (measured in %) that assesses compliance with legal quality limits for water in terms of bacteriological parameters (presence of pathogenic bacteria in the water). In the event of non-compliance, various measures can be taken to warn the public, investigate the causes and take corrective action. Physico quality is defined as an indicator (also measured in %) that assesses compliance with legal limits for water quality in terms of physico-chemical parameters such as pesticides, nitrates, chromium and bromate.

Water availability

The availability of water resources can have a significant impact on a water service's decision to cooperate. In some cases, water services may rely on external sources by importing drinking water or distribute surplus water by exporting it. We hypothesise that the degree of reliance on external resources (through imports) or the ability to support other services (through exports) may influence the choice of IMC. Services that are highly dependent on imports may have a stronger incentive to cooperate to secure stable access to water resources, while those that export water may seek cooperation to manage shared responsibilities. To analyse these dynamics, we introduce the variables Export share and Import share, which represent the share of drinking water exported or imported relative to the total volume produced by the service. We also include the variables Imported volume and Exported volume.

Control variables

We include control variables that may affect prices and the performance of an IMC structure. First, a water service may consist of many municipalities. We expect that the number of municipalities within a water service may influence the likelihood of IMC. To take advantage of economies of scale, we hypothesise that the smaller the number of municipalities within a water service, the greater the likelihood of cooperation. It has been shown that there is an optimal size for water services, beyond which economies of scale become diseconomies of scale (Garcia and Thomas, 2001; Garcia, 2003). We account for this effect by including the number of municipalities within each water service to control for the size of the IMC structure.

Moreover, the Population variable refers to the number of inhabitants served by the water utility and is also used as a control variable to account for the size of the water service. When analysed together with the number of municipalities, it can help to disentangle economies of density from economies of scale. The population served is calculated by summing the population of each municipality within the utility's service area. This continuous variable is divided into five classes: utilities serving less than 1,000 inhabitants, utilities serving between 1,000 and 3,500 inhabitants, utilities serving between 3,500 and 10,000 inhabitants, utilities serving between 10,000 and 20,000 inhabitants and utilities serving more than 20,000 inhabitants.

The price of drinking water and the likelihood of cooperation are also likely to be affected by the complexity of operations within a water service area. To account for this, we include the variable Water facilities, which measures the number of technical facilities involved in water collection, storage and distribution. A higher number of such facilities may indicate greater operational complexity, which could lead to higher costs and potentially affect price levels. In addition, this complexity may influence the likelihood of IMC, as municipalities with more extensive infrastructure may find it more advantageous to cooperate in order to share costs and resources. We also include the variable Length of network which refers to the length of pipes used to provide drinking water to the population.

4.3 Descriptive statistics

Table 3 shows the distribution of water service organisations within the sample used for the empirical analysis in this study (64,301 observations). These organisations are classified according to whether they are operated by a single municipality or through an inter-municipal structure. It is noteworthy that the majority of water services (55%) are managed by individual municipalities. Among the IMC arrangements (45% of the sample), syndicates account for the largest share, with 33% of all water services in the sample, while municipalities account for 12%.

Table 3: Summary statistics for water services organisation

Variable	Mean	Std. Dev.	Min	Max
Municipality	0.5523	0.4973	0	1
IMC	0.4477	0.4973	0	1
Community	0.1213	0.3265	0	1
Syndicate	0.3264	0.4689	0	1

Note: Obs. = 64,301.

Table 4 provides a summary of the variables used in the econometric analysis, comparing those managed by IMC with those managed by individual municipalities (without IMC). A comparison of the characteristics of water services allows us to identify the situation of services managed through IMC and those managed by individual municipalities. In

Table 4: Summary statistics for water services managed with and without IMC

Variables	**Without IMC**			**IMC**			**t-test**
	N_0	**Mean**	**S.D.**	N_1	**Mean**	**S.D.**	H_0: **Diff** = 0
Price	35,516	1.980	0.564	28,785	2.294	0.571	-69.7963
Taxes	34,874	189.7	21965.4	27,971	60.9	137.4	0.9810[1]
Public	35,516	0.709	0.454	28,785	0.397	0.489	83.7022
Produced volume	35,516	0.00027	0.00381	28,785	0.07136	11.9464	-1.1215[1]
Exported volume	35,516	0.00002	0.00023	28,785	0.00010	0.00058	-23.4300
Imported volume	35,516	0.00006	0.00034	28,785	0.00021	0.00088	-28.0785
Export share	35,516	0.030	0.098	28,785	0.053	0.118	-26.1021
Import share	35,516	0.285	0.425	28,785	0.251	0.394	10.4715
Loss index	35,516	4.174	5.890	28,785	3.151	4.036	25.079
Microbio quality	34,725	95.780	14.875	28,187	96.506	12.096	-6.6119
Physico quality	34,820	96.679	9.286	28,269	98.853	5.217	-35.1178
Length of network	35,516	37.388	173.449	28,785	207.719	370.358	-76.8914
Number of municipalities	35,516	1	0	28,785	32.167	75.565	-77.7313
Population $< 1K$	35,286	0.638	0.481	28,640	0.200	0.400	123.3775
Population $1K - 3.5K$	35,286	0.228	0.419	28,640	0.312	0.463	-24.1547
Population $3.5K - 10K$	35,286	0.092	0.289	28,640	0.264	0.441	-59.3745
Population $10K - 20K$	35,286	0.023	0.150	28,640	0.116	0.320	-48.3089
Population $20K650K$	35,286	0.014	0.116	28,640	0.063	0.243	-33.7866
Population $> 50K$	35,286	0.006	0.075	28,640	0.045	0.206	-32.9350

Prices and taxes are adjusted for inflation and expressed in constant 2015 €. [1] means non significantly different from 0.
N_0 = Obs. without IMC, N_1 = Obs. with IMC.

Table 4, we can see that the contrast between public and private management is more pronounced, as 71% of cooperating services are publicly managed, while only 40% of non-cooperating services fall under public management. A possible explanation could be that private management involves transaction costs due to negotiations with private companies.

Overall, these descriptive comparisons show price differences between water services managed by inter-municipal structures and those managed by individual municipalities. There are also differences in the size of these services.

Table 5 presents the average price (adjusted for inflation) for different management and cooperation models. The descriptive statistics first suggest that private management tends to result in a higher price than public management. This trend is observed in two scenarios: when the service is managed by an inter-municipal structure and when the service is managed by a single municipality. A second trend can be observed when comparing prices directly. Services managed by inter-municipal structures have higher prices than those managed by individual municipalities (+17.25%). This gap widens for smaller services (+18.49%), but especially for large drinking water services (+17.96%). However, this gap narrows for services where resource management is outsourced to a private company (+9.72%). For publicly managed drinking water services, the difference between services managed by inter-municipal structures and those managed by individual municipalities is 10.92%.

Table 5: Price variations for water services based on management and cooperation models (2008-2021)

Water services	**Average price**	**Std. dev.**	**Obs.**
All services	2.082	0.576	50,879
Provision mode			
Public management	1.898	0.486	30,413
Private management	2.355	0.591	20,466
Public/private gap	*+24.08%*		
Cooperation			
Services without IMC	1.942	0.536	29,648
Services with IMC	2.277	0.573	21,231
Without/with cooperation gap	*+17.25%*		
Population			
Without IMC and population $>$ 10K	1.859	0.431	1,389
With IMC and population $>$ 10K	2.193	0.482	5,364
Without/with cooperation gap	*+17.96%*		
Without IMC and population $<$ 10K	1.946	0.541	28,259
With IMC and population $<$ 10K	2.306	0.598	15,867
Without/with cooperation gap	*+18.49%*		
Cooperation and Provision mode			
Without IMC and public	1.841	0.487	21,782
With IMC and public	2.042	0.453	8,631
Without/with cooperation gap	*+10.92%*		
Without IMC and Private	2.222	0.566	7,866
With IMC and Private	2.438	0.591	12,600
Without/with cooperation gap	*+9.72%*		

Note: Calculations by the authors based on restricted samples. Prices are adjusted for inflation and expressed in 2015 constant €. The ‘public/private gap’ represents the percentage difference between public and private management, while the ‘Without/with cooperation gap’ represents the percentage difference between services without and with IMC.

5 Empirical strategy

This paper aims to identify the factors that influence the decision of water services to join IMC and their choice of organisational form, whether syndicate or community. Using an extensive panel dataset covering the period from 2008 to 2021, we estimate probit models to analyse the factors influencing municipalities' decisions to cooperate, including the choice between syndicate and community forms. However, there are several endogeneity issues that may arise when estimating the decision of cooperation.

First, the price of water may be endogenous in the decision to cooperate equation. In fact, prices are the result of negotiations between the municipality and the inter-municipal entity, which introduces a simultaneity bias.[4] Therefore, we decided to estimate a price equation and use it as a control function in estimating the probability of cooperation. Second, in both the price and the probability of cooperation equations, there may be a correlation between the explanatory variables and unobserved heterogeneity (i.e. individual effects).

To address this endogeneity issues, we apply the method proposed by Wooldridge (2015) and Lin and Wooldridge (2019), combining the correlated random effects (CRE) framework (i.e., allowing correlation between individual effects and time-varying explanatory variables) and a control function. This approach is also well suited to situations where (unbalanced) panel data analysis involves multinomial probits.

5.1 Estimation of water price

The first step in our empirical strategy is therefore to estimate a price equation (the control function). We consider a model with three types of heterogeneity, where we regress the prices Price_{ijt} paid by consumers for drinking water on the explanatory variables X_{ijt}:

$$\text{Price}_{ijt} = X_{ijt}\beta_1 + \varepsilon_{ijt}, \tag{1}$$

[4]It is worth noting that in the case of delegated management, the negotiation may also involve a private operator.

where β_1 is the coefficient to be estimated in this first step equation, and with the following error component structure:

$$\varepsilon_{ijt} = \alpha_i + \gamma_j + \lambda_t + \epsilon_{ijt} \tag{2}$$

It is worth noting that, given the unbalanced nature of the observations, it is easy to add γ_j and λ_t in X_{ijt} as dummy variables representing the six water agencies and 14 time dummies (for the observation period 2008-2021), respectively. This is what we have done in our empirical application. Furthermore, the vector X_{ijt} includes X_{ijt1}, including the water agency and time dummies, and also X_{ijt2}, the variables that are excluded in the probit equation (estimated in the second step).[5]

Hence, following Mundlak (1978), we can model α_i as correlated with the individual mean of the X_{it} computed over all time periods for each individual, denoted $\overline{X}_i$:

$$\alpha_i = \overline{X}_i \delta_1 + a_i, \tag{3}$$

where we assume that a_i is uncorrelated with each X_{ijt}. Hence, inserting equation (3) in the price equation (1), the linear model to be estimated becomes:

$$\text{Price}_{ijt} = X_{ijt}\beta_1 + \overline{X}_i \delta_1 + a_i + \epsilon_{ijt} \tag{4}$$

We make the following exogeneity assumption: $E(\epsilon_{ijt}|X_{ijt}, a_i)$, $\forall i, j$ and t. Therefore, this model can be estimated by pooled OLS, which gives consistent estimates. However, the structure of ϵ_{ijt} can introduce new problems of heteroskedasticity and serial correlation. Therefore, we estimate the equation (1) by feasible GLS in the standard RE framework and adjust the standard errors for individual clusters. It is shown that this two-way Mundlak estimator provides the within (fixed effect - FE) estimates of β_1 (Baltagi, 2023).

Finally, we can obtain the residuals $\hat{\epsilon}_{ijt}$ to enter into the probit equations of the second stage to correct for the potential endogeneity of the price in probability of IMC.

[5]Note that we do not use the same notation as in Lin and Wooldridge (2019).

5.2 Inter-municipal cooperation

The second stage of our analysis consists in estimating first the probability of being an IMC and then the possibility of being in one of the forms of cooperation organisation (communities vs. syndicates). Using a binary probit model, we first examine the factors that characterise the management of drinking water by IMCs and then estimate the probability of observing the two forms of cooperation compared to management by the municipality alone.

Similar to panel linear models, the CRE probit approach for unbalanced panel data controls for any correlation between unobserved individual effects and observed time-varying explanatory variables in the model. In addition, we correct for idiosyncratic endogeneity by introducing the residual $\hat{\epsilon}$ as an additional variable in the non-linear regression. Following Wooldridge (2019), the CRE/CF probit can be written as:

$$\begin{aligned} &P(Y_{ijt} = 1 | X_{ijt1}, \text{Price}_{ijt}, \overline{X}_{i1}, \overline{\text{Price}}_i, \hat{\epsilon}_{ijt}) \\ &\qquad = \Phi(X_{ijt1}\beta_2 + \gamma_2 \text{Price}_{ijt} + \overline{X}_{i1}\delta_2 + \theta_2 \overline{\text{Price}}_i + \rho_2 \hat{\epsilon}_{ijt}) \end{aligned} \tag{5}$$

where Φ is the standard normal cumulative distribution function. In addition, the standard errors need to be corrected for serial correlation, and for the introduction of the predicted residuals from the first step as a regressor in the second-step estimation. These corrections are made using panel bootstrap methods.

In a second model, the probability of cooperation within communities or syndicates is estimated using a panel multinomial probit model. We apply the CRE/CF approach by incorporating the residuals from our price estimation and individual means of time-varying variables, just as in the previous binary probit model.[6] Following the notations of (Wooldridge, 2010, chap. 16, p. 653–654) to specify $P(Y_{it} = j | X_{it1}, \text{Price}_{it}, \overline{X}_i, \overline{\text{Price}}_i, \hat{\epsilon}_{ijt})$ as a multinomial probit:

$$\begin{aligned} &Y_{it} | (X_{ijt1}, \text{Price}_{ijt}, \overline{X}_{i1}, \overline{\text{Price}}_i, \hat{\epsilon}_{ijt}) \\ &\qquad \sim \text{multinomial}(X_{ijt1}\beta_3 + \gamma_3 \text{Price}_{ijt} + \overline{X}_{i1}\delta_3 + \theta_3 \overline{\text{Price}}_i + \rho_3 \hat{\epsilon}_{ijt}) \end{aligned} \tag{6}$$

[6] In our case, the conditional logit model is not appropriate because the unit of observation is not the municipality but the water service (municipality or IMC), and all the variables used are individual characteristics of the services. This structure does not correspond to the assumptions of a conditional logit model, where the municipality would have to choose between alternatives on the basis of the attributes of the services.

with $j = \{0 = \text{Municipality}; 1 = \text{Community}; 2 = \text{Syndicate}\}$. Again, standard errors have to be corrected by panel bootstrap.

6 Results

6.1 Estimation of the price equation

Table 6 presents the estimation results of the price equation (1) used as a control function in the estimation of the binary and multinomial probits, respectively equations (5) and (6). In line with the framework proposed by Boyer and Garcia (2008), the pricing of water services is conceptualised as the result of a maximisation programme that varies according to the management model (public or delegated to a private operator). This framework incorporates both consumer surplus and operating costs, with the latter having a greater weight under delegated management due to the inclusion of the private operator's profit considerations. As a result, water prices tend to approximate the marginal cost of production and are influenced by factors such as the volume of water supplied, among other determinants. In addition, the public dummy variable is used to capture this difference in pricing according to the type of management. We also use the variable Taxes (in log), which represents the total amount of taxes and fees related to the service in the $120m^3$ bill, to control for the part of the water price that does not depend on cost factors.

To correct for potential correlation between unobserved individual heterogeneity and the explanatory variables, we estimate prices using a CRE approach. We include the individual mean of the time-varying variables and the individual mean of the year dummies in the price equation.[7] Therefore, an interesting test to perform to validate the use of a Mundlak approach is to perform an F-test of the null hypothesis of joint nullity of the coefficients associated with these individual means. This test is equivalent to a Hausman test of the null hypothesis of no correlation between the individual effect and the time-varying explanatory variables, but is robust to serial correlation. For our price equation, we strongly reject the null with a p-value of 0.0000, confirming the correlation between the water service-specific effect and many of the variables included

[7] We can compute individual means of the year dummies because we have an unbalanced panel data set.

in the model.

Table 6: Estimation results of the water price equation (control function)

Variable	Coef	se
Taxes	0.256***	(0.0194)
Public	-0.148***	(0.0308)
Produced volume	3.48e-05***	(3.51e-06)
Imported volume	-36.92***	(6.450)
Import share	0.100***	(0.0190)
Loss index	-0.00288***	(0.000408)
Microbio quality	0.000216*	(0.000130)
Physico quality	0.000385**	(0.000159)
Length	0.000140***	(4.50e-05)
Length^2	-1.85e-08***	(6.07e-05)
Nb of municipalities	-0.00102***	(0.000178)
Nb of municipalities^2	2.14e-06***	(4.23e-07)
Pop $3,5K - 10K$	0.0380**	(0.0151)
Pop $10K - 20K$	0.0831***	(0.0229)
Pop $> 20K$	0.0747**	(0.0329)
Constant	0.683**	(0.303)
Year FE	Yes	
Water Agency FE	Yes	
Individuals means of time-varying regressors included		
Observations	61,035	
Number of water services	10,541	
R-squared overall	0.2984	

Note: Standard errors adjusted for 10,541 clusters in water services in parentheses. Significance levels: $*** :\ p < 0.01, ** :\ p < 0.05, * :\ p < 0.10$.

The variable Taxes, in its role of controlling the part of the price that is not driven by cost factors, is found to have a positive effect on the price level. The volume of water produced also has a positive effect on the price, confirming that we are approximating a marginal cost function and not a demand function.[8]. We also find that direct public management is associated with lower water prices. When water services face environmental or organisational difficulties, local authorities delegate the management of drinking water to private companies, which pass on these additional costs in the price. (Carpentier et al., 2006; Boyer and Garcia, 2008; Le Lannier and Porcher, 2014). The variable Imported volume is found to have a positive effect on prices, indicating the trade-off between the cost of producing drinking water, depending on the availability of raw water of sufficiently good quality, and buying drinking water from another water

[8]We also try to add non-linearity by introducing the squared term of the volume, without significant result.

service to supply its own users. However, increasing the share of imported water in the total water supplied to users increases the price of water.

The index of network losses (Loss index) shows a significant and negative impact on the price paid by consumers. This result is in line with expectations, as the index serves as a proxy for the level of investment in the drinking water network. A lower network loss index indicates that the water utility has made significant investments to repair leaks, thereby improving the quality and overall efficiency of the network. Similarly, the compliance rates of distributed water samples with microbiological (Microbio quality) and physico-chemical (Physico quality) parameters show a positive and statistically significant association with water prices. This finding is consistent with the hypothesis that ensuring higher water quality involves additional costs for water utilities, which are then passed on to consumers through higher prices.

The estimation results show contrasting scale effects in the water price equation. The inclusion of variables such as the population served, the number of municipalities in the water service (Number of municipalities) and the length of the network (Length of network) allowas us to distinguish different scale effects. The inclusion of non-linearities and in particular the squared terms for both the number of municipalities (Number of municipalities^2) and the network size (Length of network^2) reveals interesting dynamics. For network size, the linear term is positive and highly significant, indicating a significant initial increase in water prices as the network grows. However, the quadratic term is negative and significant, indicating a convex relationship. This finding suggests that there are economies of scale beyond a certain network size, where additional network expansions lead to reductions in water prices. Population size effects remain consistent, with positive and significant coefficients confirming that prices increase as the population served increases. For the number of municipalities, the linear term remains negative and significant, indicating that water prices decrease as the number of municipalities increases. However, the positive and significant quadratic term indicates a slowing of this decline, with the potential for prices to rise above a certain threshold. This suggests that while economies of scale may initially reduce costs, further expansion may lead to administrative inefficiencies or other diseconomies of scale.

These findings highlight the complexity of scale effects in water pricing. While initial expansions in network size or number of municipalities may affect prices differently, the interplay between linear and quadratic terms suggests a nuanced dynamic where economies of scale emerge after certain thresholds are crossed, a result similar to that found in Garcia and Thomas (2001) and Garcia (2003). This result also suggests that the transaction costs associated with coordinating multiple municipalities may offset the potential economies of scale that could otherwise be achieved through consolidation.

6.2 Estimation of the IMC probit equation

Estimation results on the determinant of being part of an inter-municipal structure are presented in Table 7. We did not report the estimates of the individual means of explanatory variables, neither those of time dummies and weter agency dummies. However, the results of the Fisher test made on these coefficients separately indicate the importance of accounting for them. First of all, the highly significant coefficient of $\hat{v}_{it}$ (at the 1% level) derived from the control function (price equation) strongly suggests endogeneity of the price variable in the probit model estimating the probability of IMC. This is equivalent to a Durbin-Wu-Hausman test, where the null hypothesis (H_0) assumes exogeneity of the price variable (coefficient of $\hat{v}_{it}$ equal to zero). The rejection of H_0 confirms endogeneity, likely due to unobserved individual and time-varying factors influencing both price and IMC probability, which would otherwise bias the estimates of the probit model.

The prices paid by consumers are positively correlated with an IMC in the management of the water service. The estimated coefficient is highly significant at the 1% level. This suggests that water utilities managed through IMC tend to have higher prices than those managed by individual municipalities alone. This result contradicts the first hypothesis we developed in section 2. There are several possible explanations for this result. First, IMC arrangements often require additional administrative layers, such as inter-municipal boards or committees, to coordinate operations, which can lead to higher transaction and operating costs. Second, IMC often facilitates the pooling of resources for network expansion or quality improvements, such as work on recurrent leaks, resulting in higher costs that are passed on to consumers.

Third, although IMC is supposed to achieve economies of scale, this is not guaranteed.

Table 7: Estimation results of the IMC Probit

Variables	Coef	z stat	p value
Price	0.8057***	7.6296	0.0000
$\hat{v}_{it}$	-0.8058***	-8.8483	0.0000
Public	0.3764***	3.9581	0.0000
Produced volume	4.0994	0.3084	0.7500
Imported volume	141.06***	6.0968	0.0000
Exported volume	-15.725	-0.6353	0.5781
Import share	-0.0785*	-3.3642	0.0625
Export share	-0.0338	-0.5731	0.5938
Loss index	0.0052***	3.0386	0.0000
Microbio quality	-0.00050	-0.7700	0.5938
Physico quality	-0.00037	-1.0382	0.3750
Pop $3.5K - 10K$	0.0893	0.9666	0.4375
Pop $10K - 20K$	0.1735	1.4078	0.1875
Pop $> 20K$	0.1373	0.5755	0.5312
Constant	-4.7527*	-2.5457	0.0625
Year Dummies	Yes		
Water Agency Dummies	Yes		
Individuals means of time-varying regressors included			
Observations	61,035		
pseudo-R-squared	0.2718		
chi-squared	2784		
Prob $> \chi^2$	0.0000		

Note: Significance levels: $*** \, p < 0.01, ** \, p < 0.05, * \, p < 0.10$. z statistics and P-values are bootstrapped with the boottest package (Roodman et al., 2019) using the bootcluster() option to control the levels of bootstrap clustering, here the water agency.

If the economies of scale are not sufficient to offset the additional costs of cooperation, prices may rise. This explanation is confirmed by the result found in the estimation of the price equation.

We also find that the service being under direct public management is positively correlated with the likelihood of managing the resource alone. As noted above, we assume that water services under direct public management are often subject to lower transaction costs than those under private management. Therefore, it seems easier to cooperate when the mode of management is public than when it is delegated to a private operator. The variable representing water imports (Imported volume) is positively correlated with the presence of an IMC, indicating that services operating under inter-municipal cooperation agreements are more likely to import water from other providers. This may be because IMCs have larger service areas, sometimes extending into regions with insufficient local water resources, requiring imports to meet demand. In addition, IMCs may have greater financial and logistical capacity to enter into water import arrangements compared to single-municipality services.

However, the share of imported water in total water supplied to users (Import share) is significantly lower for IMCs than for single-municipality services. This suggests that while IMCs are more likely to import water, the share of imported water in their total supply remains lower. This may reflect the ability of IMCs to optimise and manage their local resources more effectively, reducing their reliance on external imports compared to single-municipality services, which may be more reliant on imports, due to resource constraints. These findings illustrate the nuanced relationship between water imports and service structure. While IMCs are more likely to engage in water imports, their relative dependence on these imports is mitigated by their greater scale and ability to share resources.

Finally, while we have previously emphasised that higher water prices may reflect better performance indicators, such as improved water and network quality, the positive correlation we observe between the loss index and IMC may seem counter-intuitive at first sight. However, this result can be explained by the possibility that municipalities with poorer performance in terms of network efficiency and water quality may be more inclined to join an IMC. This could be due to the perception (or reality) that IMCs, because of their larger size and ability to share resources, are better equipped to invest in and address network inefficiencies, repair leaks and improve overall service quality. In essence, underperforming municipal services may see joining an IMC as a strategic decision to access the financial and technical resources needed to make significant infrastructure improvements. This finding reflects the dual role of IMCs: while they are often seen as drivers of improved performance, they can also attract municipalities with existing challenges, which may initially manifest as higher loss indices in their service areas.

6.3 Forms of inter-municipal cooperation

As noted above, various forms of IMC exist in France, each with its own specificities. Water services may have different motivations when cooperating in syndicates or communities. Estimation results of the multinomial probit model are presented in Table 8.

As above in the probit equation explaining IMC vs. remaining alone, the coefficient of $\hat{v}_{it}$ is significantly different from zero, which strongly supports the existence of endogeneity of the price variable in the two equations of the multinomial probit (community and syndicate, the reference being a single municipality responsible for the water service).

Table 8: Estimation results of the multinomial probit equation

	Community			Syndicate		
Variables	Coef	z stat	p-value	Coef	z stat	p-value
Price	0.8615***	10.3445	0.0000	1.1275***	6.7735	0.0000
$\hat{v}_{it}$	-0.9400***	-7.5704	0.0000	-1.0896***	-8.0269	0.0000
Public	0.4650	2.0289	0.1562	0.4733**	6.8709	0.0156
Produced volume	5.4315	0.7595	0.5312	5.4313	0.6883	0.7188
Imported volume	125.5498*	3.0847	0.0625	182.92***	2.7186	0.0000
Exported volume	-53.9984	-0.6280	0.5938	-3.4187	-0.1723	0.9688
Import share	0.0107	0.0985	0.8438	-0.1299*	-2.5097	0.0938
Export share	-0.4972	-2.2218	0.1250	0.0890	0.7497	0.6094
Loss index	0.0169***	4.4405	0.0000	-0.0018	-1.4117	0.1875
Microbio quality	-0.0032	-1.4634	0.3750	-0.00019	-0.4455	0.7188
Physico quality	-0.0006	-0.4911	0.6094	-0.00045	-0.5293	0.5938
Pop $3.5K - 10K$	0.2820	1.1488	0.4062	0.0517	0.5826	0.6406
Pop $10K - 20K$	0.4348	1.3085	0.1875	0.0906	0.7825	0.4688
Pop $> 20K$	0.4157	0.9325	0.4062	0.0213	0.0766	0.8750
Constant	-9.9682***	-3.8982	0.0000	-3.9311	-1.4377	0.2500
Year Dummies		Yes			Yes	
Water Agency Dummies		Yes			Yes	
Individuals means of time-varying regressors included						
Observations		61,035				
Log pseudolikelihood		-41451.88				

Note: Significance levels: $***\ p < 0.01, **\ p < 0.05, *\ p < 0.10$. z statistics and P-values are bootstrapped with the boottest package (Roodman et al., 2019) using the bootcluster() option to control the levels of bootstrap clustering, here the water agency.

The coefficient of the variable Price is positive and highly significant for both 'community' (0.8615) and 'syndicate' (1.1275). This means that higher water prices are strongly associated with IMC structures compared to single-municipality management, confirming the results of the binary probit. The variable Public, which indicates public provision, is positive and significant for 'syndicates' but not for 'communities'. This result suggests that public management tends to favour the syndicate model over single-municipality structure. Syndicates, which usually operate through formal agreements between municipalities, may face greater challenges in integrating water services managed by private operators compared to individual municipalities.

We also know that a syndicate is more challenging to manage than a community, since syndicates are less political and formal than communities. Therefore, the high transaction costs associated with private management prevent services under private management from cooperating in inter-municipal syndicates. Services under public management are more inclined to join syndicates because of low transaction costs before cooperation. In contrast, communities may be more flexible and less dependent on the type of management.

The variable Imported volume, which represents the volume of water imported from external sources, is positively correlated with both 'community' (significant at the 10% level) and 'syndicate' (significant at the 1% level). This suggests that IMCs are more likely to rely on water imports than individual municipalities. Syndicates, with their larger territorial coverage, may be particularly dependent on external sources to meet the needs of their large service areas. However, the negative coefficient of the share of water imports in the total volume of drinking water supplied to users indicates that syndicates are able to reduce their dependence on external imports compared to single-municipality services and also to communities.

The water loss index, which captures network inefficiencies, is positive and highly significant for 'community' (0.0169) but not for 'syndicate'. This result suggests that municipalities with higher levels of network losses are more likely to form a community IMC than to remain as single-municipality services. This is consistent with the idea that poorly performing municipalities are attracted to community as a strategy for accessing shared resources and improving performance. The lack of significance for syndicates may reflect their more stringent organisational requirements or a greater emphasis on operational efficiency before or after integration.

7 Discussion and conclusion

This paper examines the determinants of IMC in drinking water management in France by distinguishing two levels of analysis: first, the decision of municipalities to cooperate rather than manage their service autonomously, and second, the choice of cooperation mode between syndicate and community. Using a large panel data set covering the period 2008-2021, we employ an econometric approach combining correlated random effects and a control function, which proves useful in two main ways. First, it addresses endogeneity issues arising from unobserved heterogeneity. Second, the use of a control function, specifically the estimation of a water price function, allows us to identify key cost drivers, such as service quality, as well as key constraints, including the type of management (public or delegated). This in turn provides valuable insights into the economic and institutional factors influencing the decision to engage in IMC and helps us to highlight several key findings.

The critical role of price in IMC decisions

A key insight from our analysis is the central role of water pricing in shaping the incentives and constraints that municipalities face when considering IMC. The estimation results of the price function, which is used as the control function in the IMC decision models, reveal several important cost drivers that directly affect the financial feasibility of cooperation.

First, improvements in service quality, as measured by compliance with microbiological and physico-chemical standards, but also by a lower water loss index, are strongly associated with higher water prices. This suggests that municipalities engaged in IMC may face higher costs due to the need for improved treatment processes and infrastructure investments, which are ultimately reflected in consumer prices. Second, scale effects in price dynamics provide a nuanced perspective on the efficiency of IMCs. While the number of municipalities in a water service area initially leads to lower prices due to economies of scale, our results indicate that above a certain threshold, prices start to rise. This pattern suggests that transaction costs associated with inter-municipal coordination may offset cost-saving benefits, especially when cooperation involves a large number of municipalities. Third, our results highlight the impact of management type on pricing strategies. Publicly managed services tend to have lower water prices than privately delegated services, consistent with the idea that private operators incorporate profit margins in addition to higher costs due to the complexity of service operation. This distinction is crucial for understanding IMC incentives: municipalities operating under private delegation may face higher switching costs and contractual rigidities, making IMC less attractive despite its potential efficiency gains. Finally, water import dependency emerges as a critical cost factor. Services with a larger share of external water sources in total drinking water supply have significantly higher prices, reinforcing the idea that IMC can act as a resource-sharing mechanism that mitigates supply risks. However, municipalities with limited local water resources face structural constraints that may limit the potential for cost savings through IMC.

These findings emphasise that water pricing is not just a financial indicator, but a reflection of the broader economic and institutional constraints that shape IMC decisions. By incorporating price estimation into our econometric framework, we provide a more comprehensive understanding of the trade-offs faced by municipalities, highlighting how cost structures, governance models and economies of scale interact in determining the feasibility and efficiency of IMC.

Economic and transaction cost considerations in the decision to cooperate

Our results show that the decision to engage in IMC is primarily driven by economic and technical considerations, in particular the potential to achieve economies of scale and improve operational efficiency. In theory, cooperation should allow municipalities to reduce average costs by pooling resources, optimising infrastructure maintenance and spreading fixed costs over a larger service area. However, contrary to the expectation that IMC will lead directly to lower prices for consumers (hypothesis 1), our analysis shows that inter-municipal management tends to lead to higher water prices.

This price increase can be explained by several factors. First, cooperation often involves additional administrative costs due to the need for inter-municipal coordination, governance structures and compliance with multi-party agreements. Second, the larger scale management facilitated by IMC may lead to increased investment in infrastructure, which, while beneficial in the long run, increases short-term costs that are passed on to consumers, thus invalidating hypothesis 1 in the short run. This suggests that while IMC improves infrastructure efficiency through long-term investment strategies, the cost savings may not necessarily be reflected in consumer prices due to governance-related expenditures (hypothesis 2).

Institutional constraints and the role of transaction costs

The institutional environment plays a crucial role in determining whether municipalities choose to cooperate. Our results suggest that publicly managed services are more likely to engage in IMC than privately managed services (hypothesis 3). This can be explained through the lens of transaction cost economics: in privately managed services, delegation contracts introduce rigidities and contractual frictions that increase the costs of inter-municipal coordination. Once a municipality has outsourced its water services to a private operator, modifying governance structures to incorporate IMC becomes more complex, as it requires renegotiating contracts and addressing potential conflicts between private and public interests.

Municipalities that join a syndicate tend to benefit from greater integration due to technical objectives and the possibility of more efficient service provision. In contrast, communities that operate as general agreements without specific objectives face higher coordination costs without bringing more benefits in terms of optimising service delivery. This distinction highlights the importance of considering institutional design when promoting cooperation as a policy instrument.

Service quality and organizational efficiency

Regarding the relationship between IMC and service quality, our results provide a partial validation of hypothesis 4 that cooperation improves infrastructure performance: IMC is indeed associated with higher prices, mainly due to better service quality. However, our results also show significantly lower prices in the case of communities, which are also associated with higher water losses, a key indicator of network efficiency. In the syndicate, where the water service is managed with more technical competence, long-term investments in infrastructure and maintenance are coordinated more effectively, leading to better overall performance.

IMC as a response to resource scarcity

We also test the hypothesis 5 that IMC addresses the scarcity of raw water resources by reducing dependence on external water imports. Our results show that IMC has a significantly lower water import share, particularly in the form of syndicates. This finding is consistent with the economic rationale that IMC facilitates resource pooling and risk sharing, allowing municipalities with limited access to water to secure a more stable supply.

However, while IMC helps to address short-term supply challenges, its effectiveness in structurally reducing dependence on external water sources remains unclear. We find no strong evidence that cooperation leads to long-term reductions in water imports, suggesting that IMC alone may not be sufficient to overcome geographical and environmental constraints. The persistence of resource dependence underscores the importance of complementary policies, such as investment in local water-saving technologies and adaptive infrastructure planning.

Policy implications and future research directions

These findings have several important policy implications for the governance of drinking water services. IMC should be seen not only as a means of improving infrastructure efficiency, but also as an instrument of institutional coordination. Policymakers should pay more attention to the differences between syndicates and communities when designing regulatory frameworks and financial incentives for cooperation. Encouraging deeper institutional integration in IMC could help reduce transaction costs and maximise the economic and organisational benefits of cooperation.

Furthermore, the persistence of higher consumer prices under IMC highlights the need for cost-sharing mechanisms that prevent excessive administrative and coordination costs from being passed on to end users. Policies that promote economically sustainable cooperation models, such as incentives for joint investment planning and streamlining of inter-municipal governance structures, could help to balance efficiency gains with consumer affordability.

Overall, this paper shows that IMC in drinking water management is shaped by a complex interplay of economic, institutional and technical constraints. Its effectiveness depends not only on the willingness of municipalities to cooperate, but also on the specific organisational arrangements adopted.

Future research should further investigate the long-term financial and water resource sustainability of IMCs, particularly with regard to controlling water prices and assessing IMC performance in key areas such as water quality, network efficiency and reduction of water losses. Controlling water prices is likely to require a reduction in transaction costs to ensure that administrative and coordination costs do not undermine potential efficiency gains. Meanwhile, improving service performance will depend on the adoption of better institutional arrangements designed to enhance the technical expertise of the IMC entities responsible for water management.

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