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Article

Water Markets in Spain: Performance and Challenges

Sara Palomo-Hierro [1,†], José A. Gómez-Limón [1,†] and Laura Riesgo [2,†,*]

[1] Department of Agricultural Economics, University of Córdoba, Campus Rabanales, Edif. C5, Ctra. N-IV km 396, Córdoba 14014, Spain; E-Mails: sara.palomo@uco.es (S.P.-H.); jglimon@uco.es (J.A.G.-L.)

[2] Department of Economics, Pablo de Olavide University, Ctra. de Utrera km 1, Seville 41013, Spain

† These authors contributed equally to this work.

* Author to whom correspondence should be addressed; E-Mail: laurariesgo@upo.es; Tel.: +34-954-349-851; Fax: +34-954-349-339.

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Abstract: Law 46/1999 incorporated formal water markets into the Spanish legal and regulatory framework, allowing spot water markets and the creation of water banks. The implementation of water markets in Spain aimed at improving the efficiency of water use by reallocating water towards uses with higher added value. However, the performance of water markets in Spain has been rather disappointing, since they have been operative only during drought periods, and even under these extreme scarcity situations, trading activity counted for less than 5.0% of total water use. The narrowness of the market suggests that there are some barriers hampering their effective functioning. This paper examines the evolution and performance of water markets in Spain, relying on a transaction costs analysis framework. This analysis allows the identification of the main factors impeding water markets from operating effectively as a water reallocation tool. This analysis also provides some guidelines on how to overcome these obstacles and, thus, how to improve the efficiency of water use.

Keywords: water demand management policy; water markets; water banks; market performance; barriers; Spain

1. Introduction

Over the last two decades, the water economy in Spain has faced significant changes in response to the country's socioeconomic and environmental development. During this period, Spain has become a mature water economy, characterized by a high and growing water demand, an intense competition for water resources among territories and users, an inelastic long-run water supply, aging water storage and delivery infrastructure in need of expensive repair or renovation and significant negative externalities associated with water pollution or groundwater salinization. As a consequence of this mature phase, most of the eastern and southern river basins in Spain have no margin for satisfying further water requests without reducing existing demands [1,2].

The transition to a maturing water economy has required changes in water policies, since developing new water infrastructures to satisfy increasing water demands (water supply policy) has been abandoned in favor of reallocating existing water supplies among users (water demand management policy). As is also found in other countries, economic instruments, such as water pricing, the modernization of water infrastructures and water markets, are now playing a significant role in water demand management policies in Spain, aiming to increase the efficiency of using water resources by reallocating water to user/uses with higher added value [3].

In most water-scarce Spanish areas, there is a tradition of informal water markets. These informal markets take the form of simple agreements between water users to reallocate water and require no administrative input or control by authorities [4,5]. The Reformed Water Law [6] has incorporated formal water markets into the Spanish legal and regulatory framework. This law includes the implementation of spot water markets (formal lease contracts of water rights) and the creation of water banks (water exchange centers), allowing water rights holders to temporarily trade water rights.

The potential benefits of water markets in Spain have thus far been evaluated using simulation models and not on the basis of empirical evidence [7–10]. These simulation models for water markets have shown that this economic instrument could significantly improve water use efficiency and also enhance social welfare. However, these analyses have not considered all of the legal, institutional, technical and cultural complexity of water transfers, thus overestimating the benefits gained by the implementation of water markets. In fact, since the implementation of the Reformed Water Law in 1999, there have been relatively few water transactions, most of them during the drought period (2005 to 2008) in a spot market and among agricultural users. This market narrowness makes it difficult to evaluate the actual effects of water market implementation [4].

In accordance with this situation, the aim of this paper is to address the current gap in the analysis of Spanish water markets on the basis of a review of the water trading experience in the country and the international existing literature on water markets. This allows us to: (i) identify the potential obstacles that have hampered water market performance; and (ii) suggest some reform proposals for enhancing water markets in Spain, thus improving the efficiency of water use. For this purpose, the paper is organized as follows. Section 2 provides a brief introduction together with a presentation of the regulatory basics for water markets in Spain. Next, Section 3 briefly describes the experiences of water transfers in Spain since the approval of formal water markets in 1999. Section 4 is devoted to identifying the potential barriers that may have affected water markets, by following a transaction costs

perspective. Section 5 proposes some reform recommendations for Spanish water markets in order to overcome these barriers. Finally, Section 6 concludes, providing the main insights from the study.

2. Institutional Framework of Water Markets in Spain

With the approval of Law 46/1999 [6], formal water markets were introduced in Spain via the implementation of spot water markets and water banks. Consequently, this law established the legal framework to allow water transfers between users. Both spot water markets and water banks were later consolidated into the Refunded Text of the Water Law, Executive Order 1/2001 [11], which approved the Revised Text of the Water Law (RTWL) under the title "Transfer of rights for private water use".

According to Spanish law, all water resources are in the public domain, and consequently, any private water use is subject to an administrative authorization or a legal concession (water use right), generally granted for 75 years. Nonetheless, the law allowed groundwater users to keep their private rights over groundwater if registered before 1985. Moreover, it is worth differentiating between water use rights (or concessions) and water effectively delivered to users (water allocation), which will depend on total water availability for the current hydrological year. Thus, the water volume specified in water rights is only available for users in average or wet hydrologic years, when total water availability is higher than aggregated water rights. In case of scarcity (drought years), available water resources are prioritized, with domestic water use served first. For economic uses, such as irrigation or industry, water resources are allocated proportionally in times of scarcity.

The main provisions included in the 2001 RTWL that regulate water markets in Spain are summarized below [12–15]:

- Aim of transfers: According to the law, only temporary trading of water rights (formal lease contracts and water exchange centers) is permitted (permanent transfers of water rights are not allowed). Notwithstanding, the urgent measures adopted to palliate the effects of drought on urban and irrigation areas in specific river basins, Royal Decree-Law (RDL) 9/2006 [16] and the urgent environmental measures, RDL 17/2012 [17] established some exceptions. The first RDL allowed water exchange centers to permanently acquire water use rights for environmental purposes at a fixed price, provided that this option was exceptionally approved by the government, while the second RDL introduced the possibility of permanently traded water rights by certain users in the Guadiana basin.
- Users allowed leasing water rights: Users participating in a formal lease contract (*i.e.*, buyers and sellers) must be legal holders of water use rights.
- Time and volume restrictions: The duration of formal lease contracts will be determined by the buyer and the seller, as long as the duration is equal to or less than the remaining duration of the water use right of the seller. In addition, any holder of water use rights will be able to transfer water, as long as the transferred volume does not exceed the average volume actually used during the five years prior to signing the formal lease contract. For consumptive water uses, such as irrigation, the maximum tradable water is the average volume of water actually consumed. This effective consumption is calculated as the difference between the volume of water extracted from the source and the return flows, taking into account the efficiency in the transportation, distribution and crop watering [18–20]. Regardless of the average volume of

water actually used, the volume of water transferred cannot exceed the amount of water allocated by the corresponding River Basin Authorities (RBA) on the basis of the hydrological year.

- Restrictions based on water use: There are two requisites to participate in water markets in Spain. First, the potential water seller can only lease water use rights to other holders with equivalent or higher priority in the order of preference established in Article 60 of the 2001 RTWL or according to the corresponding River Basin Management Plan. Domestic uses have the highest priority, followed by agricultural, industrial and other economic uses, such as aquaculture, recreational uses or transportation. Secondly, holders of non-consumptive water use rights (*i.e.*, hydrological uses) cannot sell their rights to holders of consumptive water use rights (*i.e.*, irrigation).
- Water authorities' intervention: The execution of a formal lease contract between users of the same river basin requires prior authorization by the corresponding RBA. A tacit consent period of two months has been established for this type of contract (*i.e.*, if no administrative resolution contrary to a formal lease contract is approved in two months, the contract is automatically authorized). During this period, the RBA may exercise a preferential acquisition right over the water volume to be transferred (right to repurchase). For contracts between users from different river basins, the required authorization is provided by the Spanish Ministry of Environment, and the tacit consent period is longer (four months).
- Pricing formal lease contracts: The price in the formal lease contract is freely agreed upon by the buyer and the seller and must be explicitly included in the contract. However, Spanish law includes the possibility of setting a price limit according to the "market situation and its imperfections".
- Water exchange centers (WEC): Spanish water law also includes the creation of water banks as an alternative to spot markets (leasing of water rights). Water banks operate in exceptional circumstances, such as severe water shortage periods or droughts. In these situations, RBAs may launch a bid for the temporary acquisition of water use rights at a fixed price (Offers of Public Purchase of Water Rights (OPPWR)) and then redistribute water volumes among potential users at a fixed price or even for free. As mentioned above, only in some exceptional cases, the government approves WEC to permanently acquire water use rights for environmental purposes.

3. Water Markets: Experiences in Spain

Water markets were introduced in Spain in 1999, and the first water transfers between users were registered one year later. However, the majority of water transfers took place between 2005 and 2008, when Spain suffered a severe drought. Experiences of intrabasin and interbasin water transfers and the role of water banks (WEC) in Spain are included below in more detail. Figure 1 shows the location of the major water transfers in Spain.

3.1. Intrabasin Water Transfers Examples

One of the most significant formal lease contracts was signed in 2002 between the Community of Irrigators (CI) Canal de Henares in Madrid (seller) and Aguas del Sorbe (buyer), a consortium for domestic water supply. They agreed to transfer 20 hm^3 per year in order to increase water availability

for urban uses (please consider the following equivalence of measurement units: 1 cubic hectometer (hm^3) = 1 gigaliter = 1 million cubic meters (Mm^3) = 811 acre-feet; and 1 hectare = 2.5 acres). The cost of the water transfer consisted of a fixed cost of 38,000 €/year, a variable cost of 0.01 €/m^3 for the first 4 hm^3 and 0.02 €/m^3 for any subsequent volume transferred. This variable cost increased up to 0.03 €/m^3 during summer periods. Despite the 10-year duration of the formal lease contract, water transfers occurred only in 2002 and 2005, accounting for 4 hm^3 and 14 hm^3, respectively [21].

Figure 1. Location of water markets in Spain.

Another formal lease contract worth noting is that signed by CI Pago de la Vega (seller) and Aguas de Almanzora (buyer), two agricultural users of the Mediterranean-Andalusian River Basin in 2007. A total of 0.9 hm^3 were transferred at a price of 0.15 €/m^3. In addition, 54 formal lease contracts were also authorized within the Segura River Basin between 2000 and 2008. These contracts allowed the transfer of 19.01 hm^3 [22].

To date, the last intrabasin formal lease contract was signed in 2011 by users of the Segura River Basin and renewed in 2012. Two cubic hectometers were transferred from the CI of Sangonera and Campo Tejar to the CI of Pulpí, at a price of 0.20 €/m^3 and assuming the pumping costs.

3.2. Interbasin Water Transfers

Most of the formal lease contracts were signed between users located in different river basins (interbasin water transfers), requiring an additional license by the Ministry of Environment for the use of public infrastructures connecting those basins.

In December, 2006, a transfer of 1.08 hm^3 of water was approved between two large farms in downstream Guadalquivir River and Aguas de Almanzora, a consortium of 18 CIs located in the Mediterranean-Andalusian River Basin. Aguas de Almanzora also bought rice farm lands close to the mouth of the Guadalquivir, with the aim of acquiring the water use rights allocated to those lands permanently. These acquisitions allowed Aguas de Almanzora to sign formal lease contracts with itself (*i.e.*, it was both the seller and buyer) and to transfer 11.97 hm^3, 3.9 hm^3 and 4 hm^3 of water in 2006, 2007 and 2008, respectively. Water was transferred from the downstream Guadalquivir River Basin to irrigate citrus trees and vegetables in northern Almeria (in the Mediterranean-Andalusian River Basin). Since this was an exceptional case in which the seller and the buyer were the same, no water price was included in the formal lease contract. However, considering that the average purchase price for the rice farms was 24,000 €/ha, the corresponding average water price was equivalent to 0.18 €/m^3 [23]. In addition, Aguas de Almanzora bought water from other CIs in 2007 and 2008: (1) 8 hm^3/year from CI Genil Cabra; (2) 5 hm^3/year from CI Guadalmellato; and (3) 4.31 and 12 hm^3 from CI Bembézar left bank and CI Bembézar right bank, respectively, in 2007. The prices for all of these transfers were about 0.18 €/m^3.

The most important water transfers occurred from the Tagus River Basin to the Segura River Basin. More specifically, the CI Canal de Estremera (upstream river Tagus) transferred water to a consortium of different CIs in southeastern Spain (Segura River Basin) called Sindicato Central de Regantes del Acueducto Tajo-Segura (SCRATS). An average volume of 31.05 hm^3/year was transferred during 2006–2008 at a price of 0.19 €/m^3 in 2006 and 0.22 €/m^3 in 2007 and 2008. Another water transfer worth mentioning is the transfer from the CI Canal de las Aves (Tagus River Basin) to the consortium Canales del Taibilla, which is responsible for supplying drinking water to more than 2.5 million people in 80 municipalities in the Segura River Basin. In this case, three formal lease contracts were signed in 2006, 2007 and 2008. The water effectively transferred was 1.18 hm^3, 8.50 hm^3 and 36.90 hm^3, respectively, at an average price of 0.27 €/m^3.

Water transfers from agricultural users in the Jucar River Basin (Unidad Sindical de Usuarios del Júcar, USUJ) to a hydropower company (Iberdrola) and to the consortium, Canales del Taibilla, have also been taking place since 2001. These contracts cannot be considered formal lease contracts, but both the purpose and the procedure were similar. Water transfers started in 2001, with volumes ranging from 6 to 12 hm^3 per year. No water price was set, but the water buyer assumed the costs for: (1) transporting water via state-owned public water infrastructures (*i.e.*, regulation and water use rates); (2) groundwater pumping as a consequence of reducing USUJ's surface water availability; (3) compensation to hydrologic users for diminishing water flows; and (4) transporting water via infrastructure connecting river basins. The total cost was estimated at 0.25 €/m^3 [21].

Finally, there has been an agreement in place between the CI Illana-Leganiel (Tagus River Basin) and SCRATS [24] (Segura River Basin) since 2011. This contract will be in effect for ten years, committing the former to sell the latter a maximum volume of 10.2 hm^3 per year, as required by

SCRATS, at a fixed price of 0.06 €/m^3. It also commits the buyer to pay the water tariffs charged to the CI by the RBA every year. This agreement can be seen as an option contract, which is not specifically included in the water law, but neither is it prohibited. In option contracts, the buyer has the right, but not the obligation, to buy the water at a future date at a pre-set price (strike price). In order to secure this option, the buyer pays an option fee to the seller for this right, regardless of whether the water is transferred or not. In this respect, the agreement between the CI Illana-Leganiel and SCRATS can be considered the first option contract signed in Spain.

3.3. Water Exchange Centers

The creation of WEC or water banks is considered an exception according to the Spanish water law, as they can only be implemented in the case of severe droughts or overexploitation of aquifers and only in specified river basins.

For the implementation of WEC, four offers of OPPWR were launched between 2006 and 2008 in order to increase the Jucar River stream flow (water purchases from irrigation to environmental uses). The first offer, in December, 2006, had a budget of 12 M€ and offered farmers the option to lease their water use rights for one year at a price ranging from 0.13 €/m^3 to 0.19 €/m^3. There were a further three OPPWRs, with budgets of 12 M€, 5 M€ and 5.5 M€ in December 2007, February 2008 and March 2008. These offers leased water use rights for 80 hm^3, 1 hm^3 and 27.5 hm^3 [25].

Another three OPPWRs were established in 2006 and 2007 in the Guadiana River Basin, and they aimed to reorganize water uses in the basin and to address the problems of the overexploitation of some aquifers. In this case, the WEC aimed to acquire water use rights from irrigators and to permanently transfer them to environmental uses. Prices varied from 3,000 € per each irrigation hectare converted to dryland farming to a maximum of 6,000 €/ha and 10,000 €/ha, depending on the presence of permanent or temporary crops, respectively. Offers were prioritized depending on: (1) the proximity of the farm to the National Park Tablas de Daimiel (an ecosystem located on an overexploited aquifer); and (2) the lowest price per hectare. Through these public offers, water use rights for 9.76 hm^3 were purchased, with a total budget of 22.28 M€. Later, in 2008 and 2009, three new OPPWRs were established to acquire water use rights for 18 hm^3 at a total cost of 42.33 M€. According to the total water rights bought and their cost, the average price paid to water right holders was 0.12 €/m^3.

Finally, there were two OPPWRs in the Segura River Basin in 2007 and 2008. The WEC provided offers to farmers upstream in the basin for the temporary acquisition of water use rights in order to reduce the effects of the drought. Water was transferred from agricultural uses to domestic and environmental uses at an average price of 0.16 €/m^3.

3.4. Aggregated Transfers

The number of both water market exchanges and users participating in the market has not been very significant in absolute terms in Spain. In addition, most of the formal lease contracts have transferred water to river basins located in the southeast of Spain (Segura and Mediterranean-Andalusian River Basins) from other river basins connected by public infrastructures (Tagus, Guadalquivir and Jucar

River Basins). This low number of users participating in water markets and their location makes the Spanish water market quite "narrow".

While the number of water market exchanges has been limited, the volume of water transferred is significant, at least in water-scarce years (drought period from 2005 to 2008). The existing difference in trade volume between normal and dry years in Spain is shown in Table 1. More specifically, Table 2 shows the volume of water transferred and used per river basin in 2007, the year when the greatest number of water exchanges was registered due to the last drought in Spain.

Table 1. Total trade volume through water markets under drought and normal conditions (hm^3). OPPWR, Offers of Public Purchase of Water Rights.

Type of Water Transfers	2001–2004 (Normal)	2005–2008 (Drought)	2009–2011 (Normal)	Total 2001–2011
Intrabasin Transfers	46.66	77.99	31.7	156.35
Interbasin Transfers		204.34	31.05	235.39
OPPWRs		198.34		198.34
Total	46.66	480.67	62.75	590.08

Note: Source: Authors' own elaboration from data in Palomo-Hierro and Gómez-Limón [26].

Table 2. Volume of water used and transferred through water markets per river basin. Year 2007.

River Basin	Total Water Use (hm^3) [a]	Intrabasin Transfers (hm^3)	Interbasin Transfers (hm^3) [b]	OPPWRs (hm^3)	Total Water Transferred (hm^3)	Total Water Transferred/Total Water Use (%)
Guadalquivir	3,790.47		(−) 33.21		33.21	0.88%
Guadiana	2,261.92			9.52	9.52	0.42%
Jucar	3,138.55		(−) 6.10	136.00	142.10	4.53%
Segura	1,820.83	0.71	(+) 74.50	3.00	78.21	4.30%
Mediterranean-Andalusian	1,337.78	0.90	(+) 33.21		34.11	2.55%
Tagus	2,830.00		(−) 68.40		68.40	2.42%
Rest of river basins	16,444.06					0.00%
Total Spain	31,623.61	1.61	107.71	138.52	247.84	0.78%

Notes: Source: Authors' own elaboration; [a] own calculations by using the annual gross water demand data included in the Water Management Plans of the different river basins and the water use data published by the Spanish National Statistics Institute; [b] positive signs show that the river basin imports water through water markets, whereas negative signs show that the river basin exports water.

According to Table 2, the Tagus River Basin transferred the greatest volume of water (2.4% of its annual water use in 2007), while the Segura and Mediterranean-Andalusian River Basins are the main buyers of water (4.3% and 2.5% of their annual use in 2007, respectively). Interbasin transfers are the most significant, and intrabasin transfers are of limited relevance in the purchasing river basins. WEC also played an important role in water reallocation, in particular in the Jucar River Basin, with transfers accounting for 4.0% of its annual use in 2007.

The data show that despite the relatively low significance of water transfers for the whole country (0.78% of total water use in a dry year, such as in 2007), markets may be quite relevant at the basin level. That relevance only happens in drought periods, such as in 2005–2008, since the number of

water transfers is almost insignificant in wet years (*i.e.*, 2010 or 2011). Therefore, under scarcity conditions, Spanish experience has shown that water markets are an effective tool for reallocating water resources to those uses with the highest economic value. The effectiveness of water markets is also reported in other countries, such as Australia, USA, Chile and South Africa [27]. In drought circumstances, Australia and Chile transferred more than 20% of their total water use by using water markets [28,29]. In California, water transferred using water markets was less, around 5% of the total water use in the region [30], showing a similar percentage to the water transfer rate registered in the Spanish south-eastern river basins. In other countries where water markets were recently implemented, such as South Africa, water transfers do not exceed 1% of the water use in any case [27].

Together with the previous conclusions, it must be highlighted that the lack of Spanish data to quantify the economic, social and environmental impacts of water transfers makes it difficult to faithfully assess whether formal lease contracts achieved their economic efficiency goals. Nevertheless, the significant volumes of water transferred from central Spain to the southeast and the water productivity difference between these territories allows us to assume that relevant improvements in water allocative efficiency have taken place, resulting in both higher aggregated incomes and job creation or job maintenance. However, water transfers may also involve some drawbacks, such as the negative impact on the rural development of the regions of origin (*i.e.*, reductions in labor and economic activity due to the substitution of irrigated crops by rain-fed crops) and the environmental effects (changes in natural water flows and their ecosystems, increased contamination in areas of destination due to the intensification of agricultural activities).

WEC have also helped to reallocate water resources with remarkable environmental benefits (*i.e.*, reduced water extraction in the case of overexploitation). However, as previously mentioned, an in-depth analysis of the role of water banks is still required to evaluate the potential socio-economic impacts of this water management instrument.

4. Main Weaknesses of Water Markets in Spain

The narrowness of water market activity in Spain, except in drought periods, may be caused by a number of factors, such as legal, administrative, cultural, psychological and technical difficulties, as well as geographical barriers [31–34]. All of these weaknesses lead us to assume the existence of high transaction costs, which are likely to reduce the number of mutually beneficial transactions and, thereby, the number of water trades that take place, causing a difference between the potential and actual water market activity.

A detailed discussion of different definitions of transaction costs can be found in Garrick *et al.* (2013), McCann and Easter (2004) and Marshall (2013) [35–37]. The definition used in this study is that provided by McCann *et al.* [38] defining transaction costs as "the cost of resources used to create and use a policy through defining, establishing, maintaining and transferring property rights". This definition has been updated by Marshall [37,39] by including the cost borne to change organizations and institutions and to define the problems that these institutions and organizations are intended to solve. Although these costs are not available for water markets and related institutions in Spain, it is possible to determine the factors affecting the magnitude of transaction costs associated with the establishment and development of water markets. According to McCann and Garrick [40], these factors can be grouped

into two categories, physical attributes (*i.e.*, scale, magnitude of change needed, users heterogeneity, excludability, external effects, measurability, potential economies of scale, uncertainty, asset specificity (e.g., dams or infrastructures for water transfers that belong to users different from those participating in water markets), *etc.*) and institutional factors (*i.e.*, culture, institutional environment, mismatch of physical and administrative boundaries, lobbying, property rights definition, market structures, existing law and policies, intermediaries, *etc*.), the interactions between both being also important. In addition, transaction costs will also depend on the initial design of property rights and the order of the reforms approved [41], issues that are addressed in the next section.

The analysis of the transactions and procedures associated with water trading in Spain permits one to analyze the structure and incidence of transactions costs. This analysis offers useful insights about those physical and institutional factors that are currently hampering the activity of water markets (increasing transaction costs). By identifying those factors, appropriate strategies can be identified in order to reduce the transaction costs and to promote higher market activity. Once factors affecting transaction costs are identified, they can be classified into three sections, according to the framework developed by McCann and Garrick [39,40]. This classification goes from those factors that are more amenable to change to those that are less amenable to modification. Any policy reform should be focused on the latter [39]. This analysis also allows identifying the necessary and sufficient modifications to achieve the desired level of water market activity, as well as the best sequence of their implementation.

Table 3 summarizes the existing relations between factors affecting transaction costs and the resulting barriers hampering water market activity. A detailed description of each of these barriers can be found in Sections 4.1–4.3. The proposals included in Table 3 to improve water markets in Spain will be addressed in Section 5.

4.1. Barriers More Amenable to Being Overcome

4.1.1. Lack of Information and Low Market Activity

Giannoccaro *et al*. [42] show that farmers' willingness to participate in water markets increases for farmers who are better informed and who have previous trading experiences. As a result of the narrowness of water markets in Spain, few farmers have any experience with formal lease contracts or WEC. Both the low market activity and the lack of information on formal lease contracts (e.g., water prices, volumes transferred or the general conditions of contracts not being made public) produce uncertainty among farmers regarding the role of water markets in allocating resources.

Table 3. Relationship among physical and institutional factors affecting transaction costs, barriers to water trade and design proposals. WEC, Water exchange center.

Barriers to Water Trade	**Main Factors Affecting Transaction Costs** [a]	**Factor Category**	**Change Amenability**	**Proposal for Policy Making**
Lack of information and low market activity	Intermediaries (+), measurability/observability (+)	Physical, Institutional	Intermediate/high	Increasing water market transparency
High fixed transaction costs	Economies of scale/scope (+), **intermediaries** (+), **assets specificity** (−), physical *vs.* administrative boundaries (−)	Physical, Institutional	Intermediate/high	Spreading water exchange centers; spreading water market functioning
Creating WEC only under exceptional circumstances and for a limited period of time	Existing law and policies (−), number of agents (+), intermediaries (+), behavioral economics (+), economies of scale/scope (+)	Physical, Institutional	Intermediate/high	Spreading water exchange centers
Lack of basin closure	Excludability (−)	Institutional	Intermediate	Make the closure of water basins official and ban new water concessions
Water rights are still attached to land by the concession system	External effects (−), property rights (−), existing law and policies (−)	Institutional	Intermediate	Regulation of permanent water use right markets
Administrative authority to grant or revise water concessions	Existing law and policies (−), Uncertainty (−)	Institutional	Intermediate	Spreading water market functioning
Ranking of water rights and water right holder requirement	External effects (−), property rights (−), **existing law and policies** (−)	Institutional	Intermediate	Removing restrictions of priority uses; removing legal right holder requirement
Allocation of water resources under drought conditions	Heterogeneity (−), uncertainty (−), property rights (−)	Physical, Institutional	Intermediate	Removing priority water allocation in drought periods
Lobbying as a nonmarket way to obtain additional water resources	Lobbying (−)	Institutional	Intermediate	Make the closure of water basins official and ban new water concessions

Table 3. *Cont.*

Barriers to Water Trade	Main Factors Affecting Transaction Costs [a]	Factor Category	Change Amenability	Proposal for Policy Making
Water market structure and imperfections	Scale (−), market structure (−), assets specificity (−)	Physical, Institutional	Low/intermediate	Spreading water exchange centers
Restrictions on interbasin water transfers due to opposition from the regions of origin	Scale (−), physical *vs.* administrative boundaries (−), institutional environment (−), existing law and policies (−)	Physical, Institutional	Low/intermediate	Guidelines on the use of infrastructures for interbasin water transfers
Communities of irrigators as decision units within the agricultural sector	Heterogeneity (−), culture (−), Institutional environment (−)	Institutional	Low/intermediate	Individual participation of irrigators
Farmer's perceptions and preferences	**Culture (−)**, uncertainty (−)	Institutional	Low/intermediate	Spreading water market functioning

Notes: Source: Author's own elaboration, adapted from McCann [39] and McCann and Garrick [40]. [a] Text in bold indicates a stronger effect, and the sign in brackets indicates whether the factor has a positive (increasing) or negative (decreasing) effect on transaction costs.

4.1.2. High Fixed Transaction Costs

High fixed transaction costs may outweigh any difference in the marginal productivity of water between buyer and seller and hamper potential water transfers [43,44]. Although there are no specific studies about this issue in Spain, fixed transaction costs are assumed to be high, since only users with significant differences in their marginal productivity of water have signed formal lease contracts. In fact, most of the water transferred has been from central Spain (extensive crops) to the southeast (urban users and horticulture crops). Moreover, the relevance of the transaction costs in Spain can be also observed in the volume of water transferred in most of the water market operations, which is greater than 1 hm^3 in most cases. This fact shows that the only way to afford these high costs is by signing large volume transfers (minimizing the average cost per volume unit transferred) [40].

4.1.3. Creating WEC Only under Exceptional Circumstances and for a Limited Period of Time

The implementation of WEC in Spain has been limited, since it requires not only exceptional circumstances (*i.e.*, severe droughts), but also a significant budget provision to launch OPPWR. Water banks have mainly focused on solving environmental problems. In fact, through WEC, water authorities have succeeded in reducing water extractions in overexploited areas by purchasing water use rights (temporary or permanent acquisitions). In contrast to what happened in California [45,46], water banks in Spain (WEC) did not act as an intermediary between potential buyers and sellers of water use rights.

4.2. Barriers Somewhat Amenable to Being Overcome

4.2.1. Water Rights are Still Attached to Land by the Concession System

By implementing formal lease contracts, the 1999 Reformed Water Law aimed to break the links between water rights and land rights. However, only formal lease contracts are allowed, and this may not be adequate when facing long-term water scarcity situations [45] due to the temporary duration of the contracts (spot water market). Water markets in Spain only improve the allocative efficiency of water use in particular circumstances, but do not allow permanent increases in water availability for users with high marginal productivity of water.

4.2.2. Administrative Authority to Grant or Revise Water Concessions

Water authorities grant private water use concessions for a maximum of 75 years, and normally, they are extended when this period expires. However, concessions might be revised during their period of validity to assess whether water users could satisfy their needs with a lower water supply. In such cases, water allotment might be reduced without any compensation. The potential revision of water concessions by water authorities introduces uncertainty and a lack of legal surety for water rights holders. Users may be dissuaded from leasing their water rights in case these transfers are interpreted by water authorities as users having an oversized water concession [47]. In any case, there is little evidence about the attitudes and behavior of different stakeholders towards the potential revision of water concessions in Spain. This barrier has been only studied by Giannoccaro *et al.* [42], who find

that while more than a half of interviewed stakeholders in the Guadalquivir River Basin were worried that their water right could be questioned by water authorities, this concern could not be confirmed in the case of farmers.

4.2.3. Ranking of Water Rights and Water Right Holder Requirement

Being a legal holder of water rights and having a similar or higher use priority than the seller are two mandatory requirements to participate in water markets in Spain. This limitation means that most formal lease contracts are signed between farmers or between farmers and urban users (*i.e.*, farmers transferring water to domestic users since the latter hold the highest water use priority). This legal barrier hampers some potential valuable water transfers between other sectors, such as those between agricultural and industrial users (*i.e.*, solar power plants) or recreational users (*i.e.*, golf courses, aquatic parks, *etc.*), regardless of the fact that they are legal water rights holders.

These legal barriers show the difficulty of merging the existing concessional system and the implementation of water markets in Spain. Considering water as a public resource makes the public administration promote and control its rational and equitable use. This means limiting private water uses according to precise conditions (*i.e.*, the activities that obtain water and the location of the water transfers must be previously authorized). This centralized approach to reallocating water resources on the basis of public interest is in direct opposition to the decentralized reallocation of the market, based on the private interests of market participants. One of the key issues is deciding which of these alternative approaches to reallocating water resources (or a combination of both) leads to the greatest social welfare in Spain [48]. So far, however, there has not been much empirical evidence collected on this issue [49,50].

4.2.4. Allocation of Water Resources under Drought Conditions

Despite water rights including the volume of water that can be used by the rights holder, in case of scarcity, water authorities can limit this quantity. In fact, actual water allotments only coincide with the amount of water established in water rights under average or wet hydrologic conditions. If the total water availability in a river basin were lower than the aggregated volume established in water rights, a water distribution system would be implemented. According to Spanish water law, a priority system determines the ranking of water users in order to allocate water in times of scarcity. Domestic users are ranked first, meaning that their water rights are served first. Once these rights have been fulfilled, the remaining water can be delivered to less senior agricultural users. By contrast, within any particular type of water use, water resources are shared uniformly amongst all users following a proportional rule.

It is worth mentioning that the proportional rule for water distribution within a water use can be modified during severe droughts. Drought plans (DP) have recently been approved in Spain for each river basin, and they include action protocols that minimize the environmental, economic and social impacts of severe scarcity conditions. Most of these DP establish that water distribution systems under scarcity must include limitations for non-priority uses and must guarantee water to keep the population healthy and to irrigate woody crops (fruit trees, olive groves, vineyards, *etc.*). This means that, in terms of water supply guarantee, water rights cannot be considered homogeneous within

agricultural use, since woody crops should be irrigated before arable crops (wheat, corn, sugar beet, sunflower, cotton, *etc*.).

The highest priority given to domestic and woody crop water users under drought conditions may discourage them from participating in water markets for two reasons. First, under drought conditions, users with higher priority may well presume that their water supply is guaranteed without operating in water markets. Secondly, the above-mentioned heterogeneity of water rights depending on the priority system confers additional uncertainty to the availability of water resources. Since RBAs are responsible for distributing water under scarcity conditions, water users must wait until public allocation decisions have been made in order to evaluate whether they should participate in water markets by leasing their water rights or by purchasing additional water resources. Analogous results have been found by Loch *et al.* [51] in South Australia, where the prospect of government assistance to horticultural farmers to protect permanent crops deterred irrigators from early water buying.

4.2.5. Lobbying as a Nonmarket Way to Obtain Additional Water Resources

Water rights granted for free in the past were preserved when water markets were approved. This fact has led to disputes between holders owning water rights without any charge and non-holders who have to buy water. Because of this, pressure groups of non-holders seek to influence government decisions regarding new water allocation and may interfere with the functioning of water markets. A number of pressure groups, especially those users located in areas of limited water resources or with expansion plans, probably lobby for new water concessions. In fact, in the past, putting pressure on government decisions was the only way to obtain new water rights, as water markets were not allowed [52].

Currently, satisfying new water demands is becoming more difficult in Spain due to the maturity or the closure of most of the river basins. In any case, because of the historical and traditional success of lobbying [53], water users belonging to these pressure groups may be less incentivized to participate in water markets, since they could expect to obtain new water rights for free as a consequence of this pressure from lobbyists. In any case, it is worth mentioning that Giannoccaro *et al.* [42] did not find the same evidence in the Guadalquivir River Basin, since they found that potential buyers of water rights would not refrain from buying water to put pressure on obtaining new (free) water rights.

4.3. Barriers Less Amenable to Being Overcome

4.3.1. Restrictions on Potential Interbasin and Interstate Water Transfers due to Opposition from the Regions of Origin

Formal lease contracts (and consequently, water transfers) require prior authorization by the corresponding RBA in the case of intrabasin water transfers and by the Spanish Government in the case of interbasin transfers, requiring coordination across state jurisdictions and river basin organizations (a mismatch of physical and administrative boundaries). In addition, interbasin water transfers require government approval to use the public infrastructure connecting different river basins. This authorization-based system resulted in a number of political conflicts among the regional

governments, since the regions of origin are usually against water transfers, whereas the regions of destination are in favor.

Political tensions and disputes regarding the authorizations required to approve water transfers have hindered the execution of formal lease contracts, in many cases impeding transfers that would improve the allocative efficiency of water use (*i.e.*, water transfers from low added value activities in the regions of origin (extensive crops) to high added value activities in the destination regions (horticulture crops and domestic uses)). An example of political tensions complicating water markets is the case of the intended formal lease contract between farmers in the Ebro River Basin (sellers) and urban users of Barcelona in the Catalonian River Basins (buyers) during the drought period of 2007–2008. Although both parties were willing to exchange water, because of a heated political debate, the government authorization needed to use infrastructures connecting both river basins was delayed for several months. However, due to the exceptional drought conditions, an urgent solution was provided in order to supply drinking water for Barcelona, without waiting for the government authorization. The situation was solved by importing water via shiploads from other regions. Thus, no formal lease contract was finally celebrated [54,55].

4.3.2. Water Market Structure and Imperfections

The water market structure may also negatively affect market functioning [3,56]. Territory division in river basins, in principle, makes water transfers possible only within each river basin. Segmentation can be avoided only by building expensive infrastructures connecting different river basins and by assuming high water pumping costs (one type of transaction cost). The relatively low size of the Spanish river basins and the high costs associated with water transfers are important barriers to the successful implementation of water markets. The limitations of the number of potential buyers and sellers participating in formal lease contracts because of physical reasons (feasibility of transfers) make water markets quite narrow, and they become bilateral oligopolies, where water allocation arrangements depend on the users' negotiation power [57]. These barriers related to market structure prevent water markets in Spain from reaching the maximum allocative efficiency of water use, since water prices do not reflect water resource scarcity in Spain. In this sense, it is worth noting that water prices indicate how much negotiating power each participant has, which results in a non-Pareto optimal allocation of water resources.

4.3.3. Communities of Irrigators as Decision Units within the Agricultural Sector

According to Spanish water law, water concessions for agricultural uses are given collectively to a group of irrigated-land owners who must be organized as a CI. These communities of users are the legal holders of water rights and not the individual landowner. This implies that the signing of any formal lease contract needs the approval of the corresponding CI. This is an administrative barrier to the implementation of water markets, since CI participation usually requires a long and complex collective decision-making process.

4.3.4. Farmers' Perceptions and Preferences

According to Tisdell and Ward [58], optimal market-based reallocation of water may occur only if farmers' social and cultural attitudes are considered in the design and implementation of water markets. Giannoccaro *et al.*, and Ortiz and Ceña [42,59,60] show farmers' resistance to trading water in Spain due to both their view of water as a non-tradable common good and the notion that water rights should not be separated from land. Cultural barriers have been largely recognized in other countries [31,56], suggesting that farmers' perceptions and preferences play an essential role in discouraging their participation in water markets.

5. Proposals to Improve Water Markets in Spain

As mentioned above, high transaction costs for water markets in Spain have promoted a low number of formal lease contracts, either between particulars or through WECs. However, and despite the narrowness of water markets, differences in water productivity between buyers and sellers allowed water markets to achieve their targets as an instrument for water reallocation when needed [60].

Strategies to reduce transaction costs are an important issue in policy design as water markets emerge. This is the case in China and South Africa, where transaction costs are still an important barrier to water trading [27]. In other parts of the world where water markets are more developed, such as the Western U.S. and Australia, initial impediments have been overcome mainly through market-enabling policy reforms on water rights (e.g., unbundling of water rights), monitoring systems and trading rules. In Spain, an improved regulatory framework is needed to reduce transaction costs and to promote water market activity. This new framework will help to consolidate the role of water markets as a resource allocation institution.

The introduction of market reforms requires considering the magnitude of change that will affect technologies, the institutional environment, governance structures or policy designs [40]. Furthermore, when deciding about the introduction of reforms, the potential benefits from trading must be balanced in relation to the transaction and expenditure costs required. Thus, once the factors that can be changed and the barriers more amenable to being overcome *versus* the factors and barriers that are more difficult to change are identified, we propose some insights and ideas that would help to improve the functioning of water markets in Spain. As was commented on previously, these proposals are ordered in decreasing priority according to their potential to reduce transaction costs compared to the resources needed for their implementation and control. These reforms could help to make the Spanish water markets more flexible and to overcome some of the problems found in the physical and institutional frameworks in which water markets operate.

5.1. Highest Priority Measures

5.1.1. Make the Closure of Water Basins Official by Law and Ban New Water Concessions

Many of the southern and eastern Spanish river basins are either closed or near closure. Water demand for consumptive uses exceeds the amount of water available in these basins, mainly due to the expansion of irrigated land during the last few decades. This has meant that most recent water rights

(water concessions) were granted for new irrigated land, reducing the water guarantee for other users in the river basin [53]. In order to avoid further water-granting inflation involving more frequent and severe shortage periods, new water demands should be satisfied only by using reallocation water mechanisms: administrative procedures (revision of water concessions) or water market implementation. Since the former may be costly for the public administration and might cause conflict with water rights holders, increasing transaction costs, water markets can be considered the most adequate tool to facilitate water reallocation under scarcity conditions.

Water markets require no additional water rights to be effective in water allocation. Banning new water concessions reduces water resource shortage and the loss of water guarantees for current users, as well as the requests from pressure groups to obtain new water concessions. Through this ban, all users would identify the market as the only way to get additional water resources.

5.1.2. Spreading Water Exchange Centers

Contrary to what has actually happened in Spain (until now, WEC have been only implemented to purchase water for environmental purposes), WEC should be generally implemented as a system to allow permanent or temporary transfers of water use rights. When compared to formal lease contracts, the main advantage of WEC is a better supervision of: (i) water demand and supply; (ii) water transfers (and potential externalities); and (iii) water price. WEC increase the transparency of water markets and reduce the transaction costs and uncertainty associated with water availability [61]. All of these benefits suggest the usefulness of implementing WEC as institutions that facilitate the interaction between potential buyers and sellers of water rights.

A regulatory framework would be necessary to promote WEC as regular water markets. Water authorities would then be responsible for authorizing water transfers once the potential economic, social and environmental impacts of water transfers were supervised. In order to facilitate water rights trading, all transfers should be authorized, except those that negatively affect social welfare [53].

5.1.3. Increasing Water Markets Transparency

Searching for information on potential water buyers and sellers, bargaining and enforcement of contracts usually imply high transaction costs. In order to promote water transfers through the market, transaction costs must be reduced. To do that, first, the water registry in Spain should be made public to reduce information asymmetry. The public information provided should include updated information on water concessions and would allow potential users to identify water use rights and any temporary private water use before negotiating any formal lease contract [62,63]. Since search and information costs would be minimized, transaction costs would be reduced. Secondly, the transparency of water markets should be improved by publicizing formal lease contracts in a timely fashion, thus reducing transaction costs associated with the bargaining process [44].

5.1.4. Spreading Water Markets Functioning by River Basin Authorities

Lack of information and limited trading experience with water markets reduce farmers' willingness to participate in water markets [42]. Some measures are needed to make farmers confident in

participating in water markets. Launching information campaigns for the CIs will help farmers better understand water market functioning. By spreading water market functioning, RBAs can not only reduce farmers' uncertainty on legal or institutional issues, but also remove any cultural barrier related to considering water as a common good that should not be traded [64].

5.2. Second Level Measures

5.2.1. Regulation of Permanent Water Use Rights Markets

Water use rights linked to land limit the participation of users in water markets, especially those users short of water resources willing to purchase new water rights. Since Spanish water law only allows temporary transfers of water use rights, structural water shortages can only be overcome by using two mechanisms. First, users short of water resources may acquire irrigated lands with their water use rights and afterwards sign formal lease contracts with themselves every year. Secondly, users may buy irrigated lands and then request the water authority to change their water concession (e.g., solar thermal energy producers might buy irrigated lands and subsequently ask for a change in water use from crop irrigation to energy production). However, the implementation of these mechanisms is not typical, since they involve high transaction costs (irrigated land purchase, management and administrative issues and potential review of water concession), as well as a lack of legal guarantee.

As previously mentioned, permanent water use rights trading was allowed temporarily and on an exceptional basis by Executive Order 9/2006 through the WEC. The permanent exchange of water use rights was only used by the Guadiana RBA to launch an OPPWR to improve the status of bodies of water.

Authorizing regular water rights (permanent) markets would promote water markets as a tool to increase water availability in the long run [56]. This would imply that the current Spanish water concession system must be withdrawn in closed or closing basins. Consequently, water authorities would not take responsibility for granting and reallocating water use rights, but they would supervise the functioning of water markets to maximize social welfare (management of environmental and social externalities caused by water transfers).

Permanent water rights markets may cause significant impacts on the population and on the environment in areas from which the water is transferred, although there is not much empirical evidence in the literature [65,66]. Permanent transfers of water use rights may imply a reduction of direct and indirect agricultural employment in the areas of origin [67] and may also cause environmental disadvantages due to fluctuations in river flows or groundwater levels, affecting biodiversity [50]. However, the potential negative environmental impacts of water markets depend on the context, and in some cases, such as in Australia, water markets brought benefits to the environment [65]. In any case, water authorities should intervene in order to prevent the potential drawbacks of permanent water use rights markets and to establish monetary compensation for those users affected by permanent water transfers (environmental and social taxes).

5.2.2. Removing Restrictions of Priority Uses in Formal Lease Contracts

An important barrier to implementing formal lease contracts is complying with the ranking of water uses. According to Garrido [68], the ranking of water uses conflicts with the attempt to make the water rights regime more flexible. Thus, removing priority uses and/or using conversion factors to address imbalance properties between the rights types would improve efficiency in the market.

Spanish water law includes the possibility of modifying the rank of water uses temporarily and under exceptional circumstances, if previously authorized by the Ministry of Environment. Such a modification occurred in 2005–2008, during the last drought period, and it aimed at increasing the flexibility of water markets to reallocate water resources. This offers a basis to make this exception the rule.

5.2.3. Removing the Requirement of Being a Legal Rights Holder to Participate in Water Markets

Allowing all users, legal rights holders or not, to participate in water markets is highly recommended since the allocative efficiency of water resources would increase. New users with a high marginal productivity of water use may participate in the market, which would generate income and create jobs without increasing water supply.

Nevertheless, participation in water markets should be regulated in order to guarantee that including new potential buyers would result in welfare improvements for the whole society (*i.e.*, verifying that new water uses will not cause significant negative externalities). In addition, speculation in water markets should be avoided; for instance, water use rights that have not been used previously (sleeper or dozer rights) should be excluded from being sold. Participation of those users that do not hold legal water rights could be effective through WEC by limiting their activities to temporary purchases of water rights. Therefore, water authorities could supervise not only water rights transfers, but also their impacts.

5.2.4. Removing Priority Water Allocation in Drought Periods

Water allocation priority under drought conditions given to domestic uses and to woody crops within agricultural uses has limited water market functioning during scarcity periods. However, this priority is justified because of the negative consequences of droughts on population health and job creation; the order of preference has been harmful for the rest of water uses (*i.e.*, decreasing water supply without any monetary compensation). In order to reduce the effects of prioritization on non-priority uses, the implementation of WEC (water banks) might be useful. According to current DPs, water bank implementation should be compulsory in the early warning stages of a drought. Water scarcity could then be addressed by reallocating water from low-value towards high-value uses, allowing the monetary remuneration of those users that agree to give up part of their water allotment. This market mechanism both increases social welfare and makes users aware of the importance of reducing water demand to mitigate the impacts of the drought [69].

5.3. Other Recommendations

5.3.1. Guidelines on the Use of Infrastructures for Interbasin Water Transfers

As mentioned in Section 3, most water transfers in Spain have been implemented between users located in different river basins during the scarcity period 2005–2008. A number of Executive Orders were published during this drought period to regulate the use of public infrastructures connecting different river basins. According to these orders, interbasin formal lease contracts were exempted from paying fees and taxes for using public infrastructures. The exemption of transportation costs contradicts the cost recovery principle and correct market functioning and, therefore, should be amended. All participants in water markets must consider the total costs of water services, preventing any additional cost for taxpayers [70].

5.3.2. Individual Participation of Irrigators in Water Markets

As previously mentioned, participating in water markets requires users to be legal holders of water use rights. This is also a barrier for those users belonging to a CI, since they cannot participate individually in water markets to buy or sell water rights (*i.e.*, CI users do not hold any water rights individually). Thus, if an irrigator wants to operate in the market, she/he needs the authorization of the CI, and usually, that authorization is not given. For efficiency's sake, each irrigator should be able to participate in water markets by trading his/her own quota of water. However, regulating individual irrigators' participation in water markets is necessary in any case to avoid both internal conflicts within the CI and the deterioration of the common management of irrigation water. For instance, some guidelines should be established to compensate the CI for the additional costs of individual water trading, e.g., the loss of any surplus from the excess of variable charges over the variable cost, and to ban any water transfer that jeopardizes the common interest of the CI [71].

6. Concluding Remarks and Future Research

In the past few decades, water markets have been proposed as a policy instrument to improve the efficiency of water use, becoming an effective and relevant mechanism in addressing water shortage problems in different regions of Australia, California and Chile [3,72–75]; indeed, by providing a price for water markets to make the opportunity cost of water explicit to users, promoting voluntary transfers from less efficient users to those who could use water more productively and providing incentives for irrigators and other water users to preserve water and adopt water-saving technologies [76,77].

In Spain, the performance of water markets falls short of this theoretical ideal. Since they were introduced, water markets have been operative only during drought periods, and even under this extreme situation, trading activity counted for less than 5.0% of total water use. Indeed, it has been only under these scarcity circumstances when water markets have seemed to be an effective tool to reallocate water resources, from low added value uses in central Spain or downstream of the Guadalquivir River, to urban or agricultural high added value uses in southeastern Spain.

Moreover, water markets should be evaluated not only on the basis of economic efficiency, but on social and environmental sustainability bases [27]. However, an integrated assessment about the

performance of water markets in Spain is not available. Thus, an in-depth analysis of the economic, social and environmental impacts would be necessary in order to evaluate the water markets' effects on social welfare, as has been conducted in Australia by Edwards *et al.*, NWC and Wheeler *et al.* [78–80].

The narrowness of the water markets in Spain suggests that there are some barriers and restrictions in their functioning, which lead us to assume the existence of high transaction costs. In this context, this paper examined the evolution and performance of water markets in Spain to determine the main factors affecting transactions costs. A transaction cost framework analysis has been used, allowing us to differentiate those physical and institutional factors that are more amenable to change from those showing a greater resistance and providing a comprehensive and logical structure for the evaluation and ranking of the proposals to improve water market functioning.

In sum, the research reported in this paper confirms the need of additional and sustained action, observing considerable room for improvement in the water market functioning in Spain before reaching maturity. However, it also highlights that the transaction costs of the different options to remove market barriers need to be carefully considered before making any decision, as well as the order and implementation of these options. According to this, the main suggested proposals for water market expansion in Spain mainly imply: (i) making the closure of water basins official by law and banning new water concessions; and (ii) promoting the joint performance of WECs and water markets with increased water market transparency.

Finally, it is presumed that Spain could certainly benefit from the experience of other countries in water markets, like Australia or the USA (California). Thus, future research should identify the relevant lessons for Spain from countries where water markets are well developed. Australian water markets, and MDB in particular, appear to be perfect alternatives for lesson-drawing, since they are considered to be representative case studies for other countries that are planning to establish water markets [27,81,82].

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Author Contributions

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Conflicts of Interest

The authors declare no conflict of interest.

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