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EVALUATION OF THE SOCIOECONOMIC IMPACTS OF THE DROUGHT EVENTS: THE CASE OF THE PO RIVER BASIN

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Abstract: The paper focuses on the socioeconomic impacts of drought events. Its objective is in particular to explore and study the distributive effects of drought events in the agricultural sector, taking the Po river basin, the most important agricultural area in Italy, as case study area. Its theoretical and methodological approach makes basis on the consumer surplus theory. One of the most remarkable outcomes of this analysis is that the effects of the drought events change considerably according to the social group. As far as agriculture is concerned, it shows that farmers and consumers are affected differently. Farmers can even earn from drought, because of the "price effect" caused by the scarcity of agricultural products; consumers always loses, because of the "quantity effect" and the "price effect". Very different impacts, in terms of sign and magnitude, were also observed among the farmers themselves, in particular when they are distinguished by crop category, and by geographical area.

Keywords: drought event; socioeconomic impacts; distributive effects; Po river basin

Sommario: Il paper si focalizza sugli impatti socioeconomici degli eventi siccitosi. Obiettivo del paper è in particolare quello di analizzare gli effetti distributivi degli eventi siccitosi nell'agricoltura, studiando il caso del bacino del Po, l'area agricola più grande ed estesa in Italia. L'approccio teorico e metodologico utilizzato si basa sulla teoria del surplus del consumatore. I risultati più rilevanti delle analisi svolte mostrano che gli effetti delle siccità sono socialmente differenziati. Nel settore agricolo si osserva infatti come l'impatto economico sugli agricoltori è diverso da quello che si registra sui consumatori. Gli agricoltori possono perfino guadagnare dalle siccità, a causa del cosiddetto "effetto prezzo", causato dalla scarsità di beni agricoli in periodi siccitosi; mentre i consumatori perdono sempre, a causa del sommarsi dell' "effetto prezzo" e dell' "effetto quantità". Impatti di segno e magnitudine diversa sono stati anche stimati tra gli stessi agricoltori, quando distinti per tipologia di coltivazione e per sub-area geografica.

Parole chiave: eventi siccitosi; impatti socioeconomici; effetti distributivi; bacino del Po

1. Introduction

Drought is a complex natural hazard that have impacts on ecosystems and on the human activities in many ways. However, no universal definition of drought exists (Lloyd-Hughes, 2014). There are several definitions and classifications of drought, for example in relation to drivers and timescales, for which it can be divided in "climate-induced", "human-induced" and "human-modified" droughts (Van Loon et al, 2016). Some of the most used drought typologies by the scientific community are also: meteorological drought, which refers to a precipitation deficiency; soil moisture drought, which is a deficit of soil moisture (mostly in the root zone); hydrological drought, a broad term related to negative anomalies in surface and subsurface water; and socioeconomic drought, that pertains to the impacts of the three above-mentioned types on the society and the economy (Tallaksen & Van Lanen, 2004).

Drought is getting a more and more frequent and intense event in the world, whose negative socio-economic effects can be remarkable, as several studies have observed, in particular in some sectors like urban water supply and agriculture (FAO; 2015; Ding et al., 2010; Stahl et al, 2015; COPA-COGECA, 2003; EEA, 2004; EEA, JRC and WHO, 2008). In rural areas, the primary sector still plays an important role, which is even increasing in the last decades, given the demographic changes at global level which raise the demand for agricultural products, and the growing value added of the agri-food value chains (WTO-OECD, 2013; USDA, 2014). This is why rural economy, like the economy of the Po river basin in Italy, is rather sensitive to the climatic changes, and in particular to water shortages caused by drought.

The studies on the impacts of drought on agriculture and rural economy are usually focused on the losses suffered in terms of crops production which burdens on the entire population (FAO; 2015; Howitt et al, 2015), but they do not analyse how these effects, in particular the effects in terms of welfare, can change according to the social group. That is to say, these studies do not take the distributive effects into account, trying to identify and estimate who "lose" and who "win" from the drought (Ding *et al.*, 2010). This analytical step appears necessary in order to better understand the consequences of drought events, and therefore to better design the adequate pro-active and reactive policies for drought risk mitigation in rural areas (for example, the subsidies for famers, which usually assume that they all lose from the drought).

In this paper, referring to the theoretical framework provided by the consumer surplus theory, we try to estimate the distributive effects of drought events, taking the case of the drought events recently occurred in the Po river basin in Italy into consideration. The first paragraph presents the consumer surplus theory. The second paragraph describes the Po river basin, its economic structure and its vulnerability to drought. The third paragraph is dedicated to the presentation and discussion of the results of the analysis of the total and the distributive effects of the drought events recently occurred in the Po basin on agriculture. Finally, the last paragraph is devoted to a concluding discussion on the results obtained, the policy implications, and the future research needed.

2. Theoretical and methodological approach

The estimate of the socio-economic effects of the drought events in the Po basin has been conducted within the theoretical framework provided by the consumer surplus theory, a well-established and entrenched theory in the context of the microeconomics[4]. The literature on the evaluation of the socio-economic impacts of drought is quite wide, and make use of several and different theoretical and methodological approaches (Logan and van den Bergh, 2011). But the application of this theoretical approach to the evaluation of the impact of drought events has been much less frequent, and limited so far to the impacts on one specific sector, urban water supply (see, for example, Woo, 1994; Garcia-Valinas, 2006; Grafton and Ward, 2008; Martin-Ortega and Markandya, 2009). So, it has never been applied to the estimation of the impacts on agriculture.

However, there are some differences between the (few) existing studies which made use of this theoretical approach, and the analysis presented in this paper. Firstly, in the case of urban water supply, water is a final product that is sold on the final consumer market, while in other sectors, such as agriculture, is a productive factor: that is to say, it is an input which contributes to the production of other products (which, on their turn, or can be sold on the final consumer market, or can be used as inputs in other value chains). Secondly, these studies measure only the losses suffered by consumers (for example, estimating and comparing losses deriving from the implementation of alternative measures, such as use of volumetric prices versus water rationing), but they never take the possible, negative or positive, effects on other social groups (for example, producers) into account. Therefore, they do not verify who loses and, potentially, who "wins" because of the drought.

Making basis on the consumer surplus theory, the socio-economic effects of drought events on crop production can be represented as shown in Figure 1. In a normal situation, that is to say when there is a normal water availability for crop production, the equilibrium point is F_1, being the intersection of the demand curve of a generic agricultural product and the supply curve[5]. In this situation, consumer surplus corresponds to the area $P_2P_0F_1$: it is therefore equal to the difference between the quantity of money consumers are willing to pay for the crop quantity Q_1, which is the area below the demand curve as far as F_1 ($P_2OQ_1F_1$), and the price that they actually pay for it, identified by the area $P_0OQ_1F_1$. Differently from normal years, in a exceptional situation, that is to say when a drought event occurs, water availability remarkably decreases,

[4] See for example Varian, 2010

[5] The supply curve is assumed to be flat, as in the short term the quantity of water available for irrigation cannot be adjusted, due to technological constraints (low degree of flexibility of the water supply and distribution networks).

and so does crop production. Then, the supply curve moves on the left, changing its slope and becoming vertical (as water availability is now strictly limited by the drought). As a consequence of this exceptional event, because of the lower supply of the hypothetic agricultural product, and the imbalance between market demand and supply, its market price increases, and the equilibrium point shifts from F_1 to F_3. Due to these changes of production and price, the consumer surplus also changes and shrinks: it is indeed now represented by the area $P_2P_1F_3$, which is apparently smaller than the area $P_2P_0F_1$.

The effects on the different groups of economic actors involved in crop production and market are not the same. Simplifiyng the structure of the value chain, and assuming that it is composed only of two groups, producers (farmers) and consumers, it is evident that the consequences for farmers are not so immediate to understand, as they are made of two different and opposite effects:

1) on the one hand, the first effect that they suffer because of the drought is the partial loss of crop production (Q_1 - Q_0). So, farmers will lose a part of the income that they could have normally obtained. This negative effect, called “quantity effect”, can be graphically represented by the area $F_2Q_0Q_1F_1$.

2) on the other hand, because of the price increase, farmers will be able to sell the (remaining) crop production at an higher price (P_1), realizing an extra-gain corresponding to the area $P_1P_0F_2F_3$. This second (positive) effect is also known as “price effect”. Therefore, while the “quantity effect” cause them a loss, the “price effect” can determine an extra-gain.

The final comprehensive economic impact on farmers will be given by the difference between these two effects, which graphically can be represented as the difference between the area $P_1P_0F_2F_3$ and the area $F_2Q_0Q_1F_1$[6].

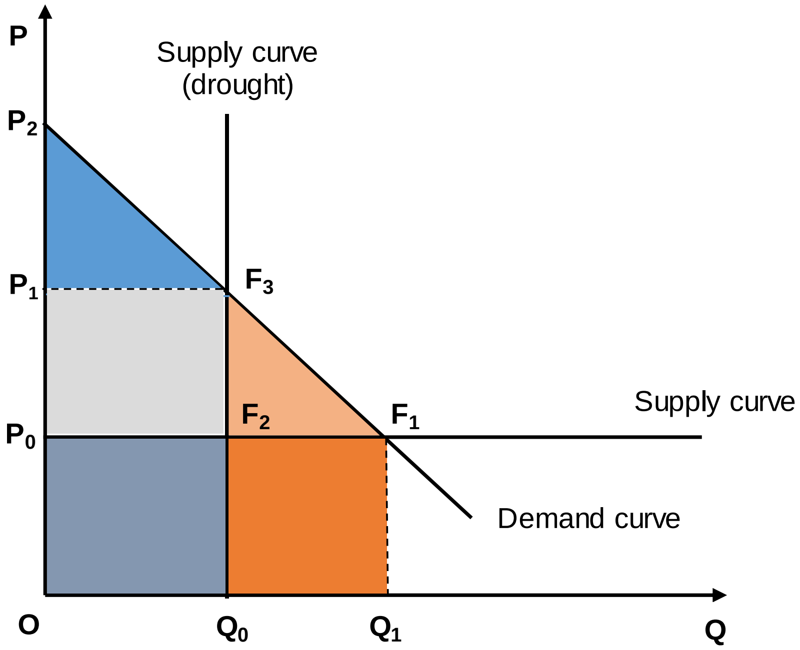

Fig 1. Effects of a drought event on crop production, according to the theoretical scheme provided by the consumer surplus theory.

[6] Needless to say, probably not all farmers will be hit by these effects to the same extent: part of them are likely not to lose any crops, and so they will only win from the combination of these effects, as they will fully exploit the price effect to increase their income and their profits, compared to the normal years. Another part of farmers probably will lose or a part or even the entire crop production, and so, in this last case, the quantity effect would exceed the price effect, causing them a net loss.

As far as consumers are concerned (the second group), it is apparent that the drought event causes an economic loss, equal to the area $P_1P_0F_1F_3$, which sums up the deadweight loss $F_3F_2F_1$, due to the welfare loss related to the lower consumption of agricultural products, and the (negative) price effect, associated to the higher price paid for consuming the agricultural products still produced in the drought year.

Taking all effects on consumers and farmers into consideration (Table 1), the social welfare change caused by the drought event relatedly to agriculture is supposed to be negative, because the community as a whole bears a loss equal to the area $F_3Q_0Q_1F_1$, which sums up the losses suffered by the consumers ($P_1P_0F_1F_3$) and the two effects observed on farmers ($P_1P_0F_2F_3$ and $F_2Q_0Q_1F_1$).

Tab 1. Effects of drought in terms of social welfare according to the consumer surplus theory.

	Quantity effect	*Price effect*	*Deadweight loss*
Farmers	$F_2Q_0Q_1F_1$ (-)	$P_1P_0F_2F_3$ (+)	
Consumers		$P_1P_0F_2F_3$ (-)	$F_3F_2F_1$ (-)
Social welfare change	$F_2Q_0Q_1F_1$ (-)		$F_3F_2F_1$ (-)

Lastly, it is worthwhile to underline that this approach is based on on some assumptions. Firstly it is assumed that the economic losses in terms of crops production are entirely caused by the drought. Secondly, it is hypothesized that such micro-economic system is not open to relations with other systems (for example, export and import) but it is self-contained, closed: this means that crops production and price are not influenced by external factors (international markets). As a last assumption, price increases are entirely transferred to the final consumers, and then they are not absorbed by any intermediate stage of the value chain (as said above, it is assumed to be a very simplified value chain, made only of producers and consumers).

3. The Po basin: a highly developed area with an important, but vulnerable, rural economy

The Po River basin, which spans around the longest river in Italy (652 km), with 141 tributary river (see Figure 2), covers a very wide area in Northern Italy (74,700 km^2), considerably rich and diversified in geographical, demographic and socio-economic terms. It accounts for a total population of about 17 millions of inhabitants, with an average demographic density of 225 inhabitants/km^2, higher than the average density in Italy (180 inhabitants/km^2). It is characterized by the presence of some big urban agglomerations, like Milan and Turin, several medium size urban centers[7], and vast rural areas, either in plain or in hilly and mountain areas[8]. Seven Italian administrative regions[9], Canton Ticino (Switzerland) and some areas in France are encompassed in it, and about 3.200 municipalities.

The level of economic development and economic vivaciousness in the Po river basin is very high: 34% of the value added of Italy is created in the Po river basin, due to a remarkable concentration of a wide range of agricultural, industrial and services activities; 29% of the Italian industrial and services firms are located there, spreading all over the basin, both in urban and rural areas. Most of the manufacturing firms are located out of the urban areas, in the industrial districts, the well known spatial model of economic development typical of the Italian economy[10]. Some of the most important sectoral specializations in manufacturing of the Po basin are

[7] Many of these urban centers are well known for their history and for their cultural and artistic heritage. Considerably valuable are also the environmental and landscaper resources, in particular the Delta area (UNESCO world heritage).

[8] According to the latest data by ISPRA (2015), consumed soil in the three administrative regions part of the Po river basin account for no more than 13% (the highest value, in the case of Lombardy), of the total surface.

[9] Piedmont, Aosta Valley, Liguria, Lombardy, Veneto, Emilia-Romagna, Tuscany and Trentino.

[10] Some of the other most representative studies were carried out by Bagnasco (1977); Brusco (1982); and Garofoli (1991).

mechanics, textile and clothing, and food. The value added produced by this last sector in the Po basin accounts for 41% of the sectoral value added in Italy[11].

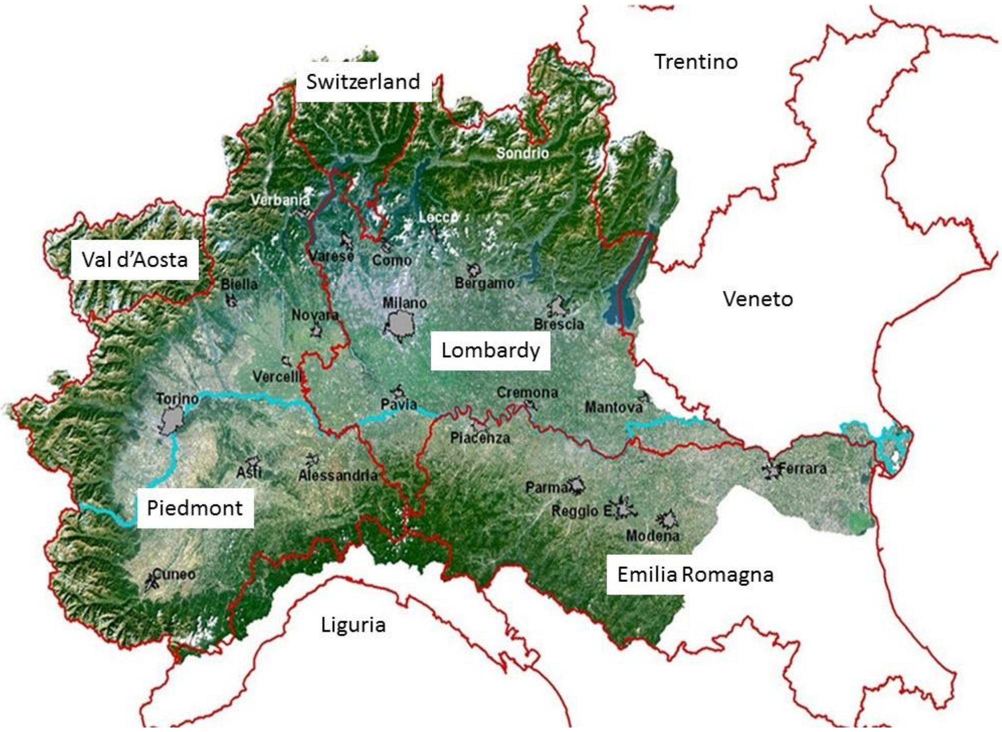

Fig 2. Administrative boundaries of the Po river basin and of the Northern Italian regions, and main urban areas. Source: Po river basin Authority

Not less important is the development of the agriculture sector, as several figures also show. A great part of the national agricultural production comes from the Po basin (35%), and the major share of the Italian livestock (55%) is produced in five provinces of the basin. 2,700,000 hectares in the Po basin are classified as utilized agricultural area (about 40% of the total basin area): 59% of them are irrigated areas. Agricultural production in irrigated areas is predominantly made of grain corn (32.5%), rice (14.5%), and alternate fodder (38,3%), in particular in the northern part of the river basin, covering about 85% of the irrigated utilized agricultural area; followed by fruit trees (4,5%) industrial crops (4,2%), and open field vegetables (3,58%)[12], more common in the southern part of the river basin.

The availability of water resources for irrigated and rainfed farming, and for other uses, is high. The average annual precipitation is 1.080 mm (calculated on the period 1923–2008). The total annual water availability supplied by precipitations amounts to 80 million m^3. The average annual flow of the Po River at Pontelagoscuro (calculated on the period 1923–2010) is near to 1.500 m^3/s. But the average annual flow, calculated on the period 2001–2010 is around 1.400 m^3/s. Total water available from Alpine lakes correspond to 1.13 billion m^3. The average annual temperature in the basin is around 5°C in the high Alps, 5–10°C in medium mountains, and 10–15°C in other zones (Autorità di bacino del fiume Po, 2016).

However, water availability, water storage and water management present considerable differences among the administrative regions part of the river basin (Lombardy, Emilia Romagna, Piedmont and Aosta valley, approximately corresponding to three geographical sub-areas in relation to their location with respect to the Po River and the Alps). The first geographical sub-area, corresponding to the territory of Lombardy, and then located north of the Po River, has a high water availability, thanks to the presence of several Alpine lakes and reservoirs, and of

[11] Calculations are based on Istat data about value added at current prices and number of active firms (2013; dati.istat.it). The area taken into consideration for calculations includes Lombardy, Piedmont, Aosta valley, and the Emilia-Romagna provinces of Piacenza, Reggio-Emilia, Parma, Modena, Ferrara.

[12] Autorità di bacino del fiume Po, 2009.

the glaciers. In Lombardy, it is therefore possible to store considerable amounts of water and to manage adequately it, releasing it if necessary, for example in case of water shortage. The second area, roughly covering the territory of Piedmont and Aosta valley, west of the river basin, has also a high water availability, but it does not have a natural and artificial storage capacity as developed as in Lombardy. The third area, which apparently covers the territory of Emilia Romagna, south of the Po river, is much poorer both of water availability and storage capacity (it is highly dependent on the water availability of Lombardy and Piedmont), but its irrigation system is considered the most technologically advanced and efficient in the Po river basin.

Notwithstanding the high level of water availability, in the last decades a progressive decline has been observed[13]. The average summer quantity of rain decreased, and the number of rainy days diminished, in particular in spring and summer time; consequently, the river flow during the dry season lowered· Moreover, from 1960 on, the average yearly temperature augmented of about 2°C, increasing the water needs for agriculture.

Given these long-term trends, since the beginning of the new millennium some drought events occurred, becoming more and more frequent. The first occurred in 2003, after a very long period of absence of water shortages caused by climatic conditions. Either very infrequent precipitations in spring and high temperatures, over the seasonal average, caused a reduction of water flows of about 50%–75%. Drought had remarkable impacts on power generation and on agriculture. The second drought event was along three years from 2005 to 2007[14]. Very recently, in 2012 and 2015, two other drought events occurred. The analyses presented in the next sections will be focused on the socio-economic impacts on agriculture of the first two drought events occurred from 2000 on.

4. Distributive effects of drought on agricultural sector

4.1 Data and Assumptions

The impacts of 2003 and 2005–2007 drought events on crop production in the Po river basin were estimated by taking into consideration time series about annual crop production provided by the Italian National Statistic Office (Istat)[15]. The analysis was conducted with reference to four crop groups (cereals, industrial crops, fruits and vegetables[16], that account for the 82% of the total agricultural production, and 40% of the total cultivated area, in the Po river basin[17].

The change in crop production (ΔQ_i) was estimated as the difference between the production at the year *i* (drought year) and the average production of the previous four years[18]. Similarly, the price change (ΔP_i) was estimated by using average annual farming prices provided by the Institute for Services for the Agricultural and Food Market (ISMEA)[19], as the difference between the price at the year *i* and the average prices of the previous four years. The monetary values of the effects of the two drought events were actualised at year 2012 [20] in order to make them comparable

[13] See Autorità di bacino del fiume Po, 2016.

[14] See Massarutto et al, 2013.

[15] dati.istat.it

[16] The aggregation in groups, although apparently causes loss of detailed information about the effects on each crop, was necessary in order to provide synthetic outcomes, comprehensive of most the wide variety of crops cultivated in the Po river basin.

[17] Istat, 2011.

[18] In order to identify the effect of drought on the production, the difference of the production between the year and the previous years was corrected by eliminating the quantity effect connected to the variation of cultivated area, due to other reasons: crop rotation, CAP subsides, etc. Monthly data about prices were not available.

[19] www.ismea.it. Data were available only at administrative regional scale (NUTS2 scale). Prices at river basin scale were therefore calculated as average of the prices in the three main regions part of the basin, Lombardy, Piedmont and Emilia-Romagna.

[20] Price actualization is calculated using deflators defined on the basis of the inflation rate time series at country level (www.inflation.eu)

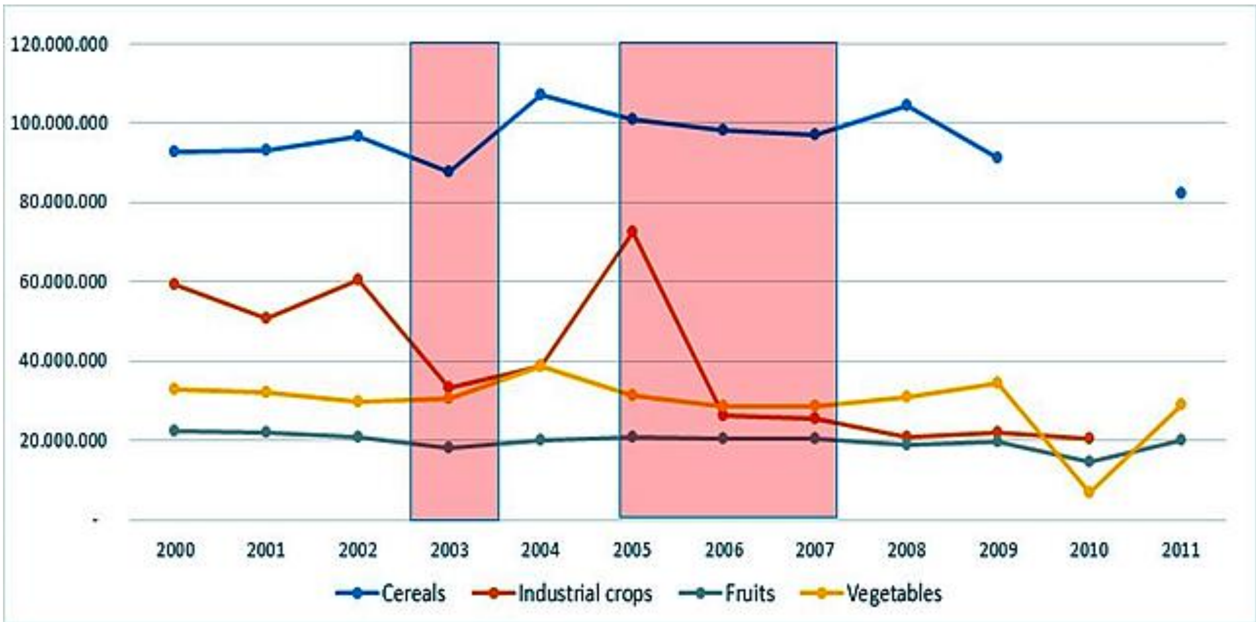

Fig 3. Yearly crop production (2000–2011; cereals, industrial crops, fruits, vegetables; 100 kg). Source: our elaboration on Istat data

Tab 2. Prices changes in the Po River Basin (2003; 2005–2007).

	ΔP_{2003}	$\Delta P_{2005-2007}$
Cereals	3.1%	13.5%
Industial crops	13.8%	9.7%
Fruits	25.7%	10.3%
Vegetables	27.1%	29.8%

Source: our elaboration on Ismea data

4.2 How different social groups are affected?

The first stage of the analysis of the distributive effects is the identification of "winners" and "losers" at the river basin scale. Making basis on the the consumer surplus theory as illustrated above, the quantity effect, the price effect, and the deadweight loss, were estimated with regards to both the 2003 and the 2005–2007 drought event.

For both cases, farmers resulted to be winners: infact, the negative economic impact caused by the decreased production (quantity effect), that concerned most of the crops categories (Figure 3), was largely counterbalanced by the positive economic impact determined by the increased prices (price effect), which was observed, as can be seen from Table 2, for all crops categories[21]. In absolute terms, the latter effect was even bigger than the former, in particular with regards to the second drought event. In the 2003 and 2005–2007 drought events farmers respectively gained approximately 700 millions of euro (Table 3) and 200 millions of euro (Table 4).

Conversely, consumers resulted to be losers in both events, therefore their welfare decreased. Not only they were hit by the negative quantity effect, but also they were negatively affected by the price effect. As regards the 2003 event, consumers lost approximately 1300 millions of euro, while in 2005–2007 event they lost approximately 820 millions of euro.

Comparing the impact of the two drought events, the total loss of welfare, for both farmers and consumers, was rather similar (approximately 600 millions of euro), but there was the a remarkable difference with regards to the price effect. So that, farmers in 2005–2007 gained

[21] Although, as explained above in footnote 8, it is assumed that not all farmers are actually winners, as a part of them probably lost all their crops.

“only” 200 millions of euro, much less than what they gained from the 2003 event (-72%), and the consumers lost less (37%).

Tab 3. Impacts of 2003 drought event (mil. Euro/year).

	Quantity effect	Price effect	Deadweight loss	Tot	Losers	Winners
Producers	-551	1.257	-	**706**		***V***
Consumers		-1.257	-41	**-1.298**	***V***	
Welfare Impact	-551	**-**	-41	**-592**		

Source: elaboration of Istat data and Ismea data.

Tab 4. Impacts of 2005 - 2007 drought event (mil. Euro/year).

	Quantity effect	Price effect	Deadweight loss	Tot	Losers	Winners
Producers	-578	778	-	**200**		***V***
Consumers		-778	-41	**-819**	***V***	
Welfare Impact	-578	**-**	-41	**-619**		

Source: elaboration of Istat data and Ismea data.

4.3 Distributive effects on different crops

The analysis presented in the previous praragraph was realized taking the entire agricultural sector in the Po River Basin into consideration. The second step of the analysis aims at estimating the economic effect on the different crops (agricultural sub-sectors), and therefore, indirectly, on different groups of farmers (differently specialized) and consumers. The analysis was especially realized on four different groups of crops (cereals, industrial crops, fruits and vegetables).

As reported in Table 5, where the effects of 2003 drought event are showed, the effects on the groups of crops are apparently rather different. Looking at the production side (farmers), the industrial crops resulted to be moderately negatively hit by the drought: indeed, for this group the magnitude of the (positive) price effect was not big enough to offset the (negative) quantity effect. On the contrary, in the case of vegetables and fruit, the former resulted to be much bigger than the latter, and so the net effect was positive. In particular, as regards fruit, in absolute terms the price effect is even ten times bigger than the quantity effect, which is extremely low (- 45.8 millions of euro). Lastly, as concerns cereals, the changes in production and price due to the drought have been positive but small, and so the effects observed for this group of crops are quite limited.

Therefore, it is possible to point out that farmers producing fruit definitely come to light as winners from the 2003 drought event, as they are the ones who had not only the greatest net benefits from the natural disaster due the price effect, but also the ones who, very limitedly (only some of them), suffered the negative quantity effect[22]. Farmers specialized in vegetables were also winners: however, the (negative) quantity effect was rather big, so clearly a not small part of them is likely that at the end lost from the drought event. As far as farmers producing cereals and industrial crops are concerned, they can be considered, only limitedly, respectively winners and losers.

Looking at the consumption side, the identification of the groups of consumers that respectively lost and gained is apparently easier: although the welfare of all consumers were reduced by the 2003 drought event, the consumers’ losses in terms of welfare in the case of vegetables and fruit clearly resulted to be the greatest.

[22] Obviously, while the price effect is assumed to affect all farmers specialized in a group of crops (all them can benefit from the increased prices), the quantity effect is assumed to affect only a part of them, as it is reasonable to suppose that not all farmers will lose their crops, and not to the same extent.

Tab 5. Impacts on farmers and consumers in the Po River Basin on 2003 drought event (Million euro/year).

		Quantity effect	Price effect	Deadweight loss	Tot	Losers	Winners
Producers	Vegetables	-422.9	685.7		262.7		V
	Cereals	42.4	47.3		89.7		V
	Industrial crops	-125.0	91.0		-34.0	V	
	Fruits	-45.8	433.3		387.5		V
	Total	**551**	**1257**		**706**		
Consumers	Vegetables		-685.7	9.4	**-676.3**	V	
	Cereals		-47.3	-2.6	**-49.9**	V	
	Industrial crops		-91.0	-19.1	**-110.1**	V	
	Fruits		-433.3	**-28.6**	**-461.9**	V	
	Total		**-1257**	**-41**	**-1298**		

Source: elaboration of Istat data and Ismea data.

Considering the 2005–2007 drought event (Table 6), and looking firstly at the effects on farmers, it is apparent that, concerning vegetables and industrial crops, the sign and the magnitude of the effects does not significantly change if compared to the previous event. Farmers cultivating vegetables are still winners, while farmers specialized in industrial crops result to be, even more apparently, losers. Instead, with regards to fruit and cereals, the outcomes of the analysis are clearly different from the ones observed for 2003 event. For fruit, the effects of the drought event are extremely modest: at the end, farmers even result to be losers. For cereals, the price effect is remarkable, and so farmers specialized in this crop production come out from the 2005–2007 drought event as winners.

Tab 6. Impacts on farmers and consumers in the Po River Basin on 2005–2007 drought event (Million euro/year).

		Quantity effect	Price effect	Deadweight loss	Tot	Losers	Winners
Producers	Vegetables	-454.8	526.7		71.9		V
	Cereals	47.4	207.6		255.0		V
	Industrial crops	-127.7	32.1		-95.6	V	
	Fruits	-43.4	11.7		-31.7	V	
	Total	**-578**	**778**		**200**		V
Consumers	Vegetables		-526.7	-41	**-567.8**	V	
	Cereals		-207.6	2	**-205.1**	V	
	Industrial crops		-32,1	-2	**-34,2**	V	
	Fruits		-11,7	-	-11,8	V	
	Total		**-778**	**-41**	**-819**	V	

Source: elaboration of Istat data and Ismea data.

Looking at the net benefits on the consumers of the 2005–2007 drought event, it is easy to notice that again vegetables is the category of crops where there were the greatest welfare loss, together with cereals, that previously did not contribute to the welfare decrease.

4.4 Distributive effects on different geographical sub-areas

A third stage of the analysis concerned costs and benefits of drought on agriculture in different geographical sub-areas that are part of the case study area, as seen in paragraph 3.

Tab 7. Impacts on producers in the different geographical sub-areas of the Po River Basin[23].

2003	**Lombardy**	**Losers**	**Winners**	**Piedmont & VdA**	**Losers**	**Winners**	**Emilia Romagna**	**Losers**	**Winners**
Vegetables	103.103.797		***V***	51.755.345		***V***	107.078.012		***V***
Cereals	43.161.917		***V***	41.975.864		***V***	- 14.417.746	***V***	
Industrial crops	- 18.135.205	***V***		- 49.859.620	***V***		77.494.178		***V***
Fruits	151.686.294		***V***	102.966.886		***V***	118.526.911		***V***
Total	279.816.803		***V***	146.838.475		***V***	288.681.355		***V***
2005–07									
Vegetables	283.014.124		***V***	294.632.547		***V***	- 182.565.512	***V***	
Cereals	726.657.505		***V***	176.627.824		***V***	3.486.960		***V***
Industrial crops	- 111.544.408	***V***		- 195.588.990	***V***		107.315.691		***V***
Fruits	- 91.455.905	***V***		115.328.759		***V***	- 382.764.154	***V***	
Total	806.671.316		***V***	391.000.140		***V***	- 454.527.015	***V***	

As shown in Table 7, summing up the effects deriving from both drought events, Lombardy and Piedmont clearly emerge always as the “winner regions”. They are those areas where farmers to the greatest extent could benefit from the combination of the quantity and the price effects caused by the drought. Respectively, in Lombardy the estimated economic benefit amount almost to 1.100,00 millions of euro, while in Piedmont they are estimated to be about 540,00 millions of euro. In particular, vegetables, which registered the biggest price changes in the drought years, resulted to be the group of crops that most contributed, without changing sign, to this outcome. Remarkable is also the contribution of cereals, in particular in Lombardy, and fruit, in particular in Piedmont. Differently from them, farmers from Emilia-Romagna could also enjoy a net positive effect from 2003 drought event, but they suffered considerable losses from 2005–2007 drought event.

It is easy to suppose that the greater water availability in the two Alpine regions allowed to contain the loss of crops (negative quantity effect), while in Emilia-Romagna the water shortage dramatically hit the crops production, notwithstanding the highest efficiency of its irrigation technologies.

[23] It is important to point out that the sum of the impacts in each region does not fully correspond exactly to the total impact as estimated and showed in Table 3, 4, 5 and 6. This slight discrepancy is due to the fact that farming unit prices (euro/ton) at basin level have been calculated as the average of the farming unit prices. Farming unit prices (kg/ton) at basin level have been infact calculated on a two steps process: (1) calculation of the farming unit price average registered at regional level, that is to say in Lombardy, Piedmont and Emilia-Romagna (for example, average of the farming price of a kg of apricots in Lombardy, Piedmont and Emilia-Romagna); (2) average of the unit prices of the agricultural products included in a crops category (for example, average of the farming unit price of a kg of apricots and of other fruits at basin level). After these two steps of calculations, an average farming unit price for each group of crops (vegetables, fruits, etc.) was available. Step 1 was not necessary for estimating the impact at regional level, as shown in Table 6. Lastly, it is also necessary to add that for some products data about farming unit prices were not always available for all three regions.

5. Concluding remarks

Several lessons can be learnt from the analysis developed in this paper, as well as implications for policies regarding droughts.

In the first place, as a popular TV series titled: “the rich cry too”. Even a territory which is commonly regarded as “water rich”may well suffer from droughts, since its vulnerability to water stress does not depend on (absolute) water availability, but rather on the intensity of water use, and on the elasticity of water demand.

The Po basin, as seen in chapter 3, owes its water richness to its favorable position, at the feet of the Alpine chain, which allows stable and reliable spring and summer flows thanks to snow melt and the storage capacity provided by lakes and reservoirs. Water is therefore easy and relatively cheap to mobilize: this can compensate the relatively hot and dry summer weather, typical of Mediterranean climate. As a result, a water-intensive economy has developed; the abundance of cheaply available water encouraged its use also for the irrigation of relatively low value-added crops, in particular in in the northern part of the river basin.

This combination of circumstances explains either the absolute magnitude of the economic costs associated to the drought events analysed, or the difficulty of adaptation.

Our estimate of the overall macroeconomic impact is rather high (-1,857 B€ in 2005–2007 event); yet it could have been up to much lower, if available water could be reallocated to the most valuable crops. What happened instead is that upstream irrigation (very low value added) had the opportunity to use water first, while downstream irrigation (high value crops) had to be sacrificed, and suffered most of the production fall. Yet reallocation is only possible when it is technically feasible to transfer available resources from one sub-region to the other. Volumetric pricing – that could incorporate scarcity in various ways – requires pressurized distribution and individual metering, and thence further investments. Moreover, use of private boreholes (that many farmers have used to compensate reduced availability from collective systems) is difficult to monitor.

However, such an event, while obviously generating huge social costs, is not necessarily bad news for agriculture. The effects of a drought affect the economic system as a whole, rather than simply the industry or sector which happens to suffer from water shortage. Although the primary sector is obviously the first one to be impacted, it is not necessarily true that farmers will also bear the economic burden – at least not all of them. Our study on the Po river basin shows that although some farmers experienced very severe effects, agriculture as a whole found the drought beneficial in economic terms, while most of the burden was shifted onto final prices.

Certainly, this approach needs further refinement, with respect to the simplifying assumptions seen in chapter 2 and to the data used. For example, as far as the structure of the value chains is concerned, future research should focus on the possibility to take all different production stages into account, in order to analyse better the transmission of the effects of the drought events along the value chains (and also the impacts on a higher number of social groups). But it also should pay more attention to some particular value chains, such as the high quality agri-food value chains, which are more and more relevant in the rural and local economy. And, as regards the data used, future analyses based on different timescales, for taking the different seasons into account, and on less aggregated crop categories, would add relevant information to the results so far obtained.

Moreover, it is clear that a single case study cannot aim at providing a definitive and robust conclusion. The geographical scope of the application of such metholodogy should be extended to other case study areas in order to gain additional empirical evidence. Further research therefore is definitely needed in order to assess the likely impacts of droughts and its distributional effects, and to design the best policies to tackle them. Expanding water supplies is not necessarily an answer, but neither is a “scholastic” application of the conventional economic theory.

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