The Unavoidable Task of Understanding Warrants Pricing

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Abstract

This paper compares the prices of derivative securities which can be considered as substitute assets and can be traded at the same moment of time. Since the late nineties, European capital markets have experienced a tremendous increase in the number of bank-issued options (warrants). Interestingly, we now have several market examples in which call and put warrants, traded on the stock exchange, and call and put options traded on the options exchange exist simultaneously. Given the relative size of the warrants traded, the Spanish capital market is a rather special case. Our research concentrates in this market. We first investigate price differences between options and equivalent warrants in terms of alternative characteristics associated with both market designs. Secondly, we compare prices of warrants with the same payoff functions but issued by different issuers. The results show that Spanish warrants are systematically overpriced with respect to options, but at an even higher level than the overpricing reported in other countries. We also document an important relative price difference between warrants depending upon the issuer. Strikingly, this difference seems to be related to who issues first the corresponding warrant.

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Introduction

Security design and market design are key concepts for understanding the price formation of financial securities. There are many and well known examples of changes in the regulation of trading mechanisms that have influenced the quality of prices and the volume of trading assets. This is, of course, a very interesting issue with serious implications not only for researchers, but also for practitioners and regulators. Hence, in recent years, a tremendous amount of financial research has been devoted to understand the impact of market microstructure on the informational efficiency of security prices.

Along these lines, differences in the way markets are designed have recently received special attention in terms of comparing primary security markets with derivatives markets.[1] Among other things, important differences between these two markets rely not only on the security design, but also on the liquidity provision functions. In primary markets these are decided by separate agents; the issuers (corporations) decide the security design (either a stock or a bond) and the market makers (or, alternatively, the electronic limit order book) play the role of liquidity providers. A detailed analysis of the implications of such separation can be found in Biais and Mariotti (2005). In any case, it should be clear that this flexibility introduces a high degree of competition in these markets. However, in a typical highly standardized derivative market, the presence of the exchange clearing house, as a common counterparty, has important consequences and limitations for both the competition of liquidity providers, and the security design. In other words, the presence of a clearing house which basically centralizes the security design function significantly affects the competition between liquidity providers. On the other hand, while inventory costs and asymmetric information are well-recognized disadvantages of fragmented markets such as the primary security markets, these costs are negligible in derivatives.[2]

Unfortunately, to study the effects of these two alternative designs on the quality of prices and trading volume is an extremely difficult task. Of course, the products traded in these two types of market are very different.

[1] Biais, Glosten, and Spatt (2005) provide an excellent survey of the market microstructure literature.
[2] See Kaul, Nimalendran, and Zhang (2004) for a recent study on the components of the bid-ask spread on derivative markets.

Since the late nineties, European capital markets with less developed derivative exchanges than the in the US, have been flooded with a large number of bank-issued options. Interestingly, these warrants are traded on special segments of the regular European stock exchanges. Thus, the recent development of warrants issued by financial entities presents an excellent opportunity to investigate the impact of market and security design on the quality and transparency of prices.

This paper analyzes the case of the warrants market in Spain. Since November 2002 these assets have been electronically traded in a special segment of the Spanish Stock Exchange (SIBE). This operating mechanism has generated a pronounced increase in the trading volume of the warrants market which, by 2003, reached the traded levels of MEFF, which is the official market of futures and financial options in Spain created in 1989.[3]

As discussed in other papers, the securities traded in warrant markets are identical or similar to standardized options. On the other hand, the warrants market design is different to the typical derivative market design. This makes a price comparison between two markets an interesting exercise which can offer new insights into how market design determines the way in which market makers act, what the investors are looking for when choosing one of these two markets, and, of course, what are the consequences for the resulting price formation process. Examples of previous literature along these lines are found in Chan and Pinder (2000) for the Australian market, Horst and Veld (2003) on the Euronext Amsterdam stock exchange, and Bartram and Fehle (2006, 2007) for the German market. These papers compare the price of traditional options and bank-issued options with similar characteristics and find significant differences indicating systematic overpricing of warrants. Horst and Veld argue that overvaluation can be attributed to a behavioral preference of private investors, while the explanation of this overpricing in the other two papers is related to differences in the market structure. Bartram and Fehle use clientele arguments, and argue that investors are willing to buy a more expensive warrant if they expect to have the possibility of selling it at a higher price. Market design, and therefore liquidity supply is responsible

[3] Interestingly, since 2003, both markets, the regular stock exchange operating under SIBE and MEFF belong to the same holding corporation known as BME (*Bolsas y Mercados Españoles*).

for the creation of such expectation investors.[4] Similarly, Chan and Pinder find that an important part of the overpricing of warrants is due to liquidity reasons such as the number of market makers competing in the market, the relative trading volume, or the possibility of electronically trading the asset. Therefore, the different characteristics of the warrants market and the options market, in either Australia or Germany, apparently show that both derivatives markets exist side-by-side with significant overlap in their products but significant differences in their prices.

This paper analyzes the bank-issued warrants market and the options markets in Spain along the lines described before. As with other countries, differences in the design of both markets exist. However, given its size, and the relative importance and flexible regulation of the warrants market, Spain can be considered as an extreme example relative to other countries. MEFF is a traditional derivatives exchange which provides standardized option contracts with a clearing house serving as a common counterparty. Thus, security design is decided by the common issuer while market makers are the liquidity suppliers. In particular, there are three market makers competing in a quote-driven electronic environment. In contrast, the warrants issuers are free to choose any characteristic of the contracts they offer. In other words, they can create products that may cover the investors' demand at any particular moment of time. Moreover, they are obliged to serve as market makers for their own products, providing liquidity in a competing market where other issuers could offer identical products and where investors can also provide prices because it is a hybrid market with a limit order book functioning simultaneously. In the case of the Spanish warrant market there are eleven authorized market makers. Finally, another difference between both markets is the possibility of being short in the options market, while the short-selling of warrants is subject to the same short-selling restrictions that apply to all common equities.

The analysis of market characteristics in determining prices may only make sense if the two markets offer competing products. *A priori,* given the freedom that issuers have in designing their warrants, we would expect to find a large variety of warrants with different characteristics with respect to the options traded in MEFF. However, evidence shows a high level of overlapping between the two markets in several European and

[4] See Fehle (2006) for a theoretical discussion on the option exchange design.

Asian countries. Again, the case of Spain is even more striking. Data from 2003 shows that 83 percent of trading volume (90 percent of the total number of contracts) in the warrants market comes from assets with the same contract terms as contracts in the options market (underlying asset, option type, exercise style, expiration date, and strike price). Therefore, if systematic differences in prices of substitute products are observed, they may be explained by different market structures in the two markets. Our results show that the average overpricing of warrants over options is approximately 22 percent. In this paper we investigate whether such a large overpricing can be explained by clientele arguments, liquidity reasons, or aspects related to market microstructure.

Additionally, we find that the size of overpricing changes between different warrants issuers. This result has not been reported previously in European markets. Moreover, market design does not seem to be useful in explaining this finding. The second objective of this paper is to investigate the potential differences in prices of equivalent warrants that only differ upon the issuer. Given that the issuer determines all contract terms, including the bid-ask spread and the volume size of the issue, we might think that the liquidity characteristic of each contract explain its price. However, using intraday transaction prices, we do not find a relationship between the differences in prices and differences in alternative proxies for liquidity. Interestingly, the issuer also establishes the first price at which a warrant is quoted. Even if we accept this initial difference, it seems that arbitrage would eliminate or reduced these differences. Our evidence shows that this is not the case. In fact, we find that for a given pair of warrants, the one issued later is the most expensive and the price difference does not decrease near the expiration date. It should be made clear that differences in credit risk among issuers can not explain the pricing differences. All issuers in the Spanish market enjoy very similar credit ratings.

The remainder of the paper is organized as follows. Section 2 describes the product characteristics and trading systems for the two alternative derivatives markets in Spain. This analysis allows us to establish some hypotheses which will be tested later. In Section 3, data and the methodology employed in matching samples are described. Section 4 discusses the relative price differences between warrants and options, and motivates potential explanations. Section 5 compares prices of equivalent warrants but issued by different issuers. Section 6 concludes.

2. Exchanged-Issued Options and Warrants (Bank-Issued Options) in Spain

While warrants were initially rights for acquiring firm shares linked to corporate bonds issues, they were later disassociated from the underlying firm. Now, warrants are issued by well known financial firms unrelated to the underlying asset. Hence, they have lost their financing role and become investment products with the same characteristics as standard options. In the case of the Spanish market, the number of warrant issues experienced an initial and relatively large growth associated with the technology boom during the late nineties. The second and more important increase in warrant issues was observed during 2003, the year immediately after a new segment of the Spanish Stock Exchange (SIBE) was created in November of 2002 to trade warrants electronically.

Figure 1 shows the evolution of the number of traded contracts in the option and warrant markets from 2000 to 2005. As we can see, there was an increase in both markets in the number of contracts traded from 2000 to 2001 associated with the increasing uncertainty of technological firms.[5] However, after 2002 the number of warrants traded carried on its increasing trend at the same time as the number of options traded was decreasing. This finding is observed until 2004, while in 2005 a slight recuperation on the option market occurred along with a small decrease in the trading volume of warrants. Thus, it appears that the introduction of the screen-based trading facility for warrants had a negative impact over the option market. Of course, the two markets have to be competing since they both offer similar products. The initial success of warrants suggests that there are some advantages linked to the warrant market that make it to expand relative to the option market after 2002. As suggested in the introduction, standardized products, in contrast to the flexibility associated with the electronic warrant market, may be behind this pattern. Somehow surprisingly, however, the subsequent evolution in both markets has been relatively similar.

The first objective of this paper is to analyse these questions by comparing transaction prices of similar options and warrants traded in the two competing markets. Before presenting the main results of the paper, it seems convenient to describe the trading system in both markets, and the product characteristics to understand precisely the level of institutional overlapping. All the information provided below refers to 2003.

[5] The level of the scale in both graphs is not comparable given that the size contract in options is larger than in warrants.

Table 1 describes the main characteristics of the option market and the warrant markets in Spain. One important difference between them is related to the liquidity supply. While the option market in Spain is a quote-driven market where market makers are the only institutions allowed to quoting prices, in the case of warrants we have a hybrid market with a limit order book and specialists. Moreover, each specialist works for the firm that issued the warrant because the issuer commits himself to make a market for its own contracts quoting at least one price in both sides of the book until option's expiration. Thus, investors always have the possibility of making a transaction at a price quoted by specialists or can *make a market* by putting a limit order in the book. Under this arrangement, competition is assured.

Contrary to the flexibility and available information in the warrant market, some liquidity requirements are not as clear in the case of options. The standardized option market is a quote-driven market with three market makers who can trade any contract. Although they are obliged to quote prices in each session, we have observed that only one ask price or bid price is available at most instants during the sessions. Moreover, they are trading contracts that they have not designed and, therefore, these are contracts which are not necessarily forced to be hedged because the last and common counterparty is the clearing house. Thus, we can expect that competition is less aggressive in this market with the possibility of lacking liquidity. The rest of characteristics abstracted in the Table 1 are very similar in both markets. For example, investors can trade electronically through an intermediary in both markets; the transparency level is basically the same; and the length of the trading session is quite similar.

Unlike standard options, it is very important to point out that it is not possible for investors to sell short bank-issued options. This fact has potential implications for arbitrage strategies between equivalent options. Let us assume that an option and a warrant on the same underlying assets have identical payoff functions but different prices. Benefits from arbitrage may exist if the warrant is cheaper than the option. In the opposite case, given the inability of investors to short the warrant, the arbitrage opportunity does not really exist.

Comparing the security characteristics of the two markets in Table 2, we observe, once again, that all terms for option contracts are standardized, in contrast with the freedom that banks have when issuing a new contract. We can find warrants over a variety of underlying assets and with longer expiration dates. This standardization also makes options have larger contract sizes than warrants. For options on stocks the contract size is 100 underlying assets, while the contract size in warrants lies in a range between 0.1 and 2. Similarly, one option on the future on the Ibex-35 index is associated with one underlying asset, and the ratio for warrants on the index goes from 0.001 to 0.002. Then, *a priori*, the contract terms could be specific for warrants with the implication that both markets may not have to be necessarily competitors in products if warrant issuers opt for differentiated securities.

Table 3 contains the composition of the option and warrants markets. This allows us to easily extract the level of overlapping. During 2003, trading volume in warrants was 1609.8 million euros. It is a small quantity when compared to other markets such as the stock market, but it should be noted that just one year after starting negotiating in their segment at SIBE, the trading volume in warrants became larger than the trading volume of the traditional derivative market. Unlike standard options, warrant contracts are predominantly calls. Given the freedom of the issuers to establish the option type, it is possible to think that this finding responds to the investors' demand. It suggests that investors participate in this market due to speculative reasons rather than having a hedging motivation.

The underlying assets in option contracts are standardized. The market allows trading in twenty national stocks and one equity market index (Ibex 35 mini-future). In the case of the warrant market, a much larger variety of underlying assets are possible (27 different stocks with two thirds of the total volume), but 91.5 percent of the trading volume in warrants trade on the same underlying assets than the options. Moreover, the 20 stocks that serve as the underlying assets for standard options are also underlying stocks of the warrant contracts. The trading volume within these contracts (1047.5 million euros) represents almost 99 percent of the trading volume in warrants on individual stocks.

On the other hand, regular financial options have generally short-term horizons with standardized expiration dates: third Friday of March, June, September or December.

Again, the freedom in the warrant contracts allows the issuer to establish long-term maturity warrants and flexible expiration dates. However, Table 3 shows that more than 96 percent of the trading volume in either individual stocks or the market index corresponds to contracts with the same expiration dates as in the option market. Lastly, 83 percent of the total available warrants in our sample have simultaneously the same underlying asset, strike price and expiration date than existing options. Thus, a very relevant part of the contracts traded in the warrants market presents the same characteristics than contracts traded in the options market. On the contrary, only 23 percent of the trading volume in the option market has an equivalent warrant. It seems that, given the additional flexibility that the warrant market enjoys relative to the highly standardized derivative market, warrants issuers are able to offer differentiating products. However, most warrant products were already trading in the official derivative market.

In any case, it is interesting to point out that the warrant market was particularly concentrated on individual securities where the availability of alternative products is quite large. In this sense, the creation and the subsequent successful expansion of the warrant market occurred in a competitive environment. These facts may suggest a clientele movement from the option market to the warrant market. On the other hand, as pointed out above, only 23 percent of the trading volume in the traditional option market corresponds to similar products in the new market. Hence, it may not be necessarily the case that the tremendous decrease in the trading volume of the option markets (from 24 million contracts in 2002 to 11 million contracts in 2004) is explained by the boom in the new market.

3. Data and Matching Samples

We first collect data on all options traded in MEFF during 2003. They are options on twenty Spanish individual stocks: Acesa, Acerinox, Altadis, Amadeus, BBVA, Bankinter, Endesa, Gas Natural, Iberdrola, Indra, Inditex, Banco Popular, Repsol YPF, Santander, Sogecable, Telefónica, Telefónica Móviles, TPI, Terra, and Unión Fenosa; and one option on the Spanish future index, which is known as Ibex35 mini-future. We find 12,490 different options according to the following characteristics: underlying asset, type, strike price, and expiration date. All options on individual stocks are American style and have a size contract of 100. Options on the index are European style

and have a size of 1. We also obtain data on warrants traded in SIBE on the 21 underlying assets described earlier, with expiration dates which are always available in the options market. There are 1,684 different warrants where different issuer warrants are counted individually. We collect information about the contract characteristics of all warrants and options in our sample. All warrants trading at SIBE are American style and have different sizes, which are determined by the ratio.

Then, from the two samples above we select equivalent options, i.e., options and warrants with identical underlying asset, expiration date, strike price and type. This exercise results in a matched sample of 1,007 options and 1,278 warrants. We can now find an option traded in MEFF with the same payoff function for 76 percent of the warrants issued on the 21 underlying assets and the expiration dates selected. On the other hand, only 8 percent of all different options available in MEFF have a competitor in the warrant market.

Table 4 offers descriptive figures of coinciding options in both markets. In each panel, columns two and three report the total number of different options and warrants on the 20 underlying stocks and the index, while the expiration dates are displayed in the first column of the Table. Columns 4 and 5 indicate the number of options or warrants for which a warrant or an option with identical underlying asset, expiration date, type, and strike price exists. Given the obligation of issuing pairs of equivalent call and put options, we have the same number of puts and calls. However, there are twice as many call warrants as put warrants. On the other hand, the proportion of coinciding options in both markets is larger for puts, and this proportion is especially high in the case of warrants on the market index. Regarding the expiration dates, the highest level of overlapping occurs for warrants expiring on December 2003. Since the sample contains live contracts during 2003, this is probably due to the fact that this expiration date is in the middle of all possible expirations.

We then collect a complete history of time stamp of intraday transactions from January 2, 2003 to December 30, 2003 for all options and warrants from the matching sample. Our options data contain the transaction price, the cumulative volume after each transaction, and the bid and ask prices and depths before each transaction. All this data is provided by MEFF. The available information for warrants consists of transaction

prices and volume, and the bid and ask prices and depths before and after each transaction. This information is provided by *Sociedad de Bolsas*.

In addition, we compute the following variables for all options and warrants from the matching sample: the daily level of moneyness as the ratio between the underlying asset closing price and the strike price for calls and the inverse for puts; the daily number of days to maturity; the intraday relative bid-ask spread just before each transaction and the cumulative volume, in number of underlying assets, traded in the 15 days preceding each transaction day.

The next step consists of matching transaction prices for all these pairs of options which provide investors with identical (or very similar) payoff functions. We decide to use transaction prices instead of quotes because, in the case of options traded at MEFF, the latter are missing in most time periods. The procedure is as follows. For each option price we search the nearest equivalent warrant transaction price. Then we compute the time difference between the two transactions within each pair. Figure 2 shows the histogram of these differences. It is rather striking to note that, for most cases, both options in each matching pair are traded close to each other in time (less than five thousand seconds) in their respective markets. Moreover, it turns out that the distance in seconds between transactions is smaller than one hour in 75 percent of all available pairs. Thus, our first matching criteria are that all price pairs have a time difference of no longer than one hour. This yields 12,636 price pairs. Other matching pairs are obtained with more restrictive temporal criteria as a maximum distance: half an hour, fifteen minutes, and seven and a half minutes. The number of price pairs in each case is 9,516; 6,955 and 4,810 respectively.

As we already mentioned, the size contract in regular options is standardized to 100 underlying assets, while the size contract in warrants is much smaller. This suggests that the euro volume of an option transaction is potentially larger than the volume of the equivalent warrant transaction. With this institutional constraint in mind, a second criterion of matching transaction prices consists of selecting those which have the nearest volume from transactions with no more than one hour as the maximum distance. In this case we obtain 9,135 price pairs. Finally, in order to be more precise, we restrict the price pairs to those in which the time distance between transactions is less than one

hour and trading volume in warrants on stocks is a multiple of 100 underlying assets. The number of pairs in this case is 3,447.

4. The Price Comparison between Equivalent Options and Warrants

4.1. What is expected?

In principle, since the two options in each pair have identical payoffs functions (with the exception of the quantity, given the different size contracts between both derivatives), important and systematic differences in their prices should not be observed when the two transactions occur near in time. However, empirical evidence shows that the overpricing of warrants occurs in many countries.[6] The reason that may be explaining such overpricing is the prohibition to short-selling warrants. Hence, arbitrage opportunities between warrants market and options market can not exist. Our first aim is to verify if a higher price of warrants is also observed in the Spanish market. The exercise is especially interesting because, unlike other countries, both the warrants market and the traditional options market belong to the same holding corporation in Spain, namely BME (*Bolsas y Mercados Españoles*).

In any case, if there were overpricing, we still need to explain why investors would be willing to pay a higher premium if a standard option appears to be a close substitute. The assumption of agent rationality suggests that if there are two very similar products trading at different prices in alternative market scenarios practically at the same time, investors would choose the cheapest market. Moreover, if these price differences persist, the expensive market could disappear. Otherwise, the potential differences in prices may have to be associated with different market structures. Our analysis is based on this fact. Indeed, there exist different reasons related to the market structure that could justify, at least partly, a higher price for warrants. Specifically, we explore whether the overpricing may be related to different clienteles or market-making quality and discuss its consequences on liquidity.

The argument of different clienteles is supported by the study of Bartram and Fehle (2006). They show that if an investor looks for speculative opportunities and, therefore, he has a high probability of liquidating its derivative position before the expiration, he

[6] Chan and Pinder (2000), Bartram and Fehle (2006), or Petrella (2006) are some examples.

would be willing to pay a higher ask price for the warrant than for the option if he expects the future bid price for the warrant to be also higher than the future option bid price. Moreover the expected difference between futures bid prices should be higher than the difference between current ask prices. Of course, this expectation can only be supported if the warrants market presents narrower bid-ask spreads consistently. This is the case of the German market. Bartram and Felhe (2007) find that, on average, traditional options have bid-ask spreads 43 percent higher than bank-issued options.

Some characteristics of the market structures and securities in the two Spanish derivative markets are consistent with the argument of heterogeneous investors. First, warrant issuers provide more calls than puts while the use of the option for hedging suggests that investors would need to buy puts rather than calls. Secondly, the size contract in warrants is much smaller than in options, so individual investors/speculators would probably choose the warrants market, while institutional investors with hedging needs would use the option market. Moreover, after conversations with practitioners, we understand that no investor in the warrant market has ever exercised his option positions. Lastly, the higher level of market making competition in the warrants market suggests that smaller bid-ask spreads should be observed. Our second analysis tries to investigate theses questions.

The other explanation for the overpricing of warrants that we consider is related to liquidity. On the one hand, as asset pricing theory has proved, an investor will be willing to pay a premium when buying an asset if the asset can be easily sold later at a reasonable price. Thus, higher prices of warrants could be explained by higher liquidity levels found in then warrants market relative to the options market. On the other hand, the heavy competition that warrants market provide with a limit order book, also suggests that it would be a more liquid market. The third issue that we investigate is whether the overpricing is cross-sectional related to differences in liquidity between the two derivatives markets.

4.2. Relative Price Differences

For each price pair of matching transactions according to the criteria described in Section 3, we compute the relative difference (*RP*) between warrant and option prices,

$$RP = \frac{P_W - P_O}{P_O} \tag{1}$$

where P_W and P_O are the transaction warrant price and option price respectively.

We compute the number of positive relative price differences, the number of negative differences, and the cases in which both prices are equal. Then, we compute the mean and the median of *RP* and, because of the skewness observed in the series, we only analyze the statistical significance of the median by the Wilcoxon Signed Rank test. Table 5 shows the results. *P-values* for the tests of the median equal to zero are not reported because the null is always rejected for all cases. This is done for the total number of pairs and for observations grouped according to the option type, underlying asset, and warrant issuer. Table 5 shows the results. Panel A contains the statistics for price pairs with no more than one hour distance between transactions; in Panel B the price matching criteria is a maximum distance of 7.5 minutes between transactions; the results in Panel C correspond to the criteria of matching transactions with the closest volume, and with a time difference of less than one hour; and Panel D reports the results for transaction pairs with the same restriction as in Panel C, but now the trading volume in the warrant contract is a multiple of 100 underlying assets. In this case, we only employ options on individual stocks.

Independently of the underlying asset, the option type, the warrant issuer, or the matching criteria, a systematic pattern is clearly observed in the results. Transaction prices in the warrant market are higher than transaction prices in the option market. On average, and using the median instead of the mean, we find a 25 percent overpricing of warrants when we use intraday data and impose a maximum distance of one hour between transactions. The relative difference in prices is a bit lower when restricting the time distance between the two transactions. In particular, the overpricing is 22.64 percent for half an hour, 20.69 percent for fifteen minutes, and 19.36 percent for 7.5 minutes. For all cases, the null hypothesis of median relative price differences equal to zero is always rejected at the 1 percent level of significance. These results are quite surprising. As we indicated in the previous section, an overpricing of warrants may be expected, but the magnitude of the difference is much larger than the overpricing found

to other countries. Chan and Pinder (2000) find a median overpricing of around 3 percent for intraday transactions in the Australian derivative market. In the case of Bartram and Fehle (2006, 2007), they use quotes instead of prices and compare ask quotes and bid quotes separately, for options traded in the Euwax market (bank-issued options) and for options traded in Eurex market (standard options) in Germany. They find that Euwax ask and bid quotes are higher than Eurex ask and bid quotes (4.7 percent and 9.9 percent respectively). Other markets show similar results.[7]

We may try to explain such a large overpricing by the possibility of investors willing to trade small amounts of the underlying through the use of warrants; or alternatively, it may be the case that option market institutional investors may benefit from lower prices when trading large quantities. However, when we limit the matching process to warrant transactions with a size volume available in the option market, we still obtain a median overpricing of 17 percent (Panel D).

Results in Table 5 also show that the level of overpricing is independent of the option type, and that the average overpricing in warrants is even more extreme for options on the index than for options on individual stocks. Moreover, we find significant differences in prices among warrant issuers. We will come back to this finding in the next section.

4.3. Clienteles Hypothesis

As we pointed out before, the argument of differentiated clienteles in both derivatives markets has been used to explain different prices in products with equivalent payoffs (Bartram and Felhe, 2006). Individual speculators would trade in the warrants market instead of in the options market, although the first one is more expensive, if they could obtain larger gains with the sell than the costs with the buy.

We now compare relative prices differences by distinguishing between buy initiated transactions (ask) and sell initiated transactions (bid) with the criterion of one hour as a maximum time distance and with the closest volume. This is a fairer comparison

[7] Petrella (2006) for the Italian case is another example. Horst and Veld (2003) report an average overvaluation in the Euronext Amsterdam exchange between 25 and 30 percent for warrants when they compare market prices with theoretical prices given by three popular option pricing models. This is, of course, a different exercise.

because we are matching transactions in the same side of the spread. Moreover, this exercise allows us to test whether differences in bid prices are larger than differences in ask prices, supporting the argument of higher potential earnings in the warrant market for speculative investors. Table 6 contains the relative percentage pricing difference from this exercise. Panel A reports ask price differences, while Panel B displays bid quote differences. As in Table 5, all relative price differences are statistically significant in median at a level of 1 percent. The relative difference between ask transaction prices on the one hand, and bid transaction prices on the other, are very similar. In fact, the difference in bid prices is slightly lower than the difference in ask prices.

To be more precise, in order to investigate if transactions costs are the reason behind the choice of the warrants market by a speculator, we now compare the relative bid-ask spreads for all the transaction pairs. We compute the relative spread just before each transaction for the two markets with the matching criteria of transactions with the closest volume and with a time difference of less than one hour. As before, Table 7 reports the results of mean and median differences between the relative spreads. The number of pairs is now reduced to 6781 (instead of 9135 pairs in Table 5, Panel C) given the missing values in one of the two sides of the spread in whatever market. Specifically, it is not possible to compute the relative spread for 1254 warrant transactions and for 1302 option transactions. Asterisks indicate that mean or median difference between the two relative spreads is statistically different from zero.

With respect to the mean differences it is observed that they are generally positive, indicating that transaction costs in the warrants market are higher than in the options market. This evidence would not support the hypothesis of speculator clientele in the warrants market for justifying its overpricing. However, analysing the median differences, we observe that they are negative in most cases and statistically different from zero for all transaction pairs, for call derivatives, and for issuers 1, 6, and 7. In general terms, the median of relative spread differences does not seem to be particularly large. For all pairs the option market is only a 0.042 percent more expensive than the warrants market. This small reduction of transactions costs in trading warrants instead of options does not appear to be a sufficient justification for speculative investors to chose the warrants market and to pay higher prices that amount to a 22 percent average

difference.[8] However, and curiously, the differences in spreads are higher when the issuers of the warrant are the numbers 6 or 7 (1.8 percent and 1.1 percent respectively), who are the issuers that present the higher levels of overpricing.

Comentar el sesgo por missing values. Ahora ya no sé si este sesgo nos beneficia o perjudica porque el número de observaciones perdidas es muy similar en warrants y en opciones.

Summarizing our findings at this point, it seems complicated to give a completely rational explanation of the striking success of the Spanish warrant market relative to the traditional option market. An important part of the market clearly overlaps with the existing option market; transaction prices for warrants, for which options with the identical payoffs exists, are higher on average; in many cases the trading volume in the warrant transactions is not smaller than the minimum standardized size of the option counterpart; and the bid-ask spreads in the warrant market are only a bit smaller than the spreads for equivalent options. In the next section we look for additional understanding on these issues.

4.4. Warrants Liquidity Premium

A potential explanation for different option and warrant prices is the presence of a liquidity premium. The relative bid-ask spread is the most common proxy for liquidity. As we already pointed out, relative bid-ask spreads are similar on average for equivalent transactions in both warrants market and options market. However, it may be the case that cross-sectional changes in relative price differences are related to different liquidity levels. In order to investigate this possibility we now carry out a multivariate regression analysis. Our aim here is to test whether the relative price differences (*RP*) for the matched transactions are related to some explanatory variables associated to liquidity reasons.

Of course, one of these liquidity variables is the relative bid-ask spread. Specifically, for each matched transaction we compute the ratio between the relative spread just before the transaction in the option and the relative spread just before the transaction in the warrant (*RSP*). Additionally, assets with a higher level of activity are more liquid

[8] In the case of the German market, Bartram and Felhe (2006) find an average bid-ask spread of 2.8 percent in Euwax while the bid-ask spread in Eurex is 7.1percent.

(Easley, et al., 1996). Thus, the trading activity also contains information about the degree of liquidity in a market. Then, the second liquidity variable that we consider is the ratio that compares the trading volume in options to the trading volume in warrants during the 15 days preceding each matched transaction (*RVOL*).

Given the overpricing of warrants and our hypothesis of the existence of a liquidity premium, we expect the relationship between *RP* and *RSP* to be positive, while the relationship between *RP* and *RVOL* should be negative.

Other variables capture some well known patterns in the behaviour of option prices. Derivative prices change in response to variations in the underlying price, and time-to-expiration. Therefore, we also employ as control variables, moneyness degree (*MONEY*) and the number of days to expiration (*TTE*) of the two options in each matching pair. Trading activity in derivatives tends to increase when options are at-the-money or time-to-expiration is short. Thus, a large number of the transaction price pairs are expected to be found for both short-term to expiration and at-the-money options. Figure 3 clearly displays this pattern for the number of pricing pairs. We represent moneyness against the number of days to expiration for options in each pair, and for calls and puts separately. In both graphs we observe a concentration of observations on the left side of the graph (less than 90 days to maturity). Moreover, matching options are mostly out-of-money when time to expiration is more than 90 days. Only when transactions get close to expiration, option pairs are located around the at-the-money positions. This is especially true for puts, whereas for calls, there is a trend to find in-the-money transaction pairs the closer we are to expiration. In fact, the correlation between *TTE* and *MONEY* is highly negative and equal to -0.47.[9] The pattern on this Figure suggests that warrants with equivalent options are used to obtain returns by liquidating positions instead of exercising the options.

On the other hand, some researches have documented that bid-ask spreads and trading volume are larger at the beginning and end of the trading day in stock exchange

[9] Because of this high correlation, we use the residual from *MONEY* on *TTE* when including the two variables in the regression below.

markets.[10] To control for this intra-day effects we include two dummy variables: *OPEN* for transactions that take place from 9 to 11, and *CLOSE* for transactions that take place in the last two hours of the session (from 15:30 to 17:30). Similarly, although we do not find important differences in relative prices between calls and puts, but given that the number of pairs is greater for calls than for puts, we also include a dummy variable to distinguish the option type (*CALL*). Finally, we have observed important differences in warrant overpricing between different issuers. Thus, we specify four dummy variables (D_i) to record pairs in which the warrant issuer is the number *i*: 1, 4, 6, and 7. Pairs in which the warrants are issued by issuer 5 are not considered because the lack of ask or bid prices makes us impossible to compute the *RSP* variable. The specific sample used for this regression is composed of pairs obtained with the matching criteria of choosing the warrant-option transactions with the closest volume over all pairs formed with one hour as a maximum time distance. The number of observations is 6,781.

Table 8 presents the results from the OLS estimation of following regression,

$$\begin{aligned} RP_n = \beta_0 + \beta_1 Money_n + \beta_2 TTE_n + \beta_3 RVOL_n + \beta_4 RSP_n + \beta_5 CALL + \\ + \beta_6 OPEN + \beta_7 CLOSE + \beta_8 D_1 + \beta_9 D_4 + \beta_{10} D_6 + \beta_{11} D_7 + u_n \end{aligned} \quad (2)$$

We first run the regression with the full cross-sectional sample as described above, and later we run the same regression for individual stocks and the market index separately.

Given the definition of the independent variables, β_0 represents the average relative price difference for pairs of puts, in which the warrant is issued by issuer 9 (who is in the middle of the range of observed overpricing), and for transactions made during the intermediate trading session. The p-value of statistical significance is reported below each estimate.

Generally speaking, the results indicate that most variables explain the relative price difference between warrants and options with the exception of the dummy controlling for the end of the trading day. The signs of the estimated coefficients are as expected. The difference in prices is smaller when the options are at-the-money or when the

[10] See McInish and Wood (1992) and Chan et al. (1995) for the US market and Rubio and Tapia (1996) for the Spanish market.

options are close to expiration; the overpricing of warrants is larger for relatively more liquid warrants; that is, when the *RSP* is large and when *RVOL* is low; the overpricing is also larger for calls than for puts, and also for transactions during the initial hours of trading, and for issuers 6 and 7. As exceptions, *RVOL* and *OPEN* are not statistically significant in explaining differences in prices between warrants and options on individual stocks. Finally, the explanatory variables explain between 37 percent for individual stocks to a high 57 percent for the case of the market index

To summarize the evidence, we can assert that the warrants traded in the Spanish stock exchange are more expensive than similar options traded in the regular standardized option market. There is some evidence suggesting that this difference in prices is related to the heterogeneity of investors in both markets. The larger number of call warrants relative to available puts or the fact that investors do not exercise them suggest that investors are predominantly speculators. Unfortunately, for the evidence to be fully consistent with this hypothesis, we should observe smaller bid-ask spreads in the market for warrants. Otherwise, it would be very difficult to understand why investors may be willing to pay a higher price when buying a warrant if a cheaper equivalent option exists. Our data show that spreads in warrants are only a bit smaller than spreads in options and the median difference between both is only significant in some cases. Of course, we have to be cautious in interpreting this result. Our data are taken from 2003, the first year after the incorporation of warrants to the electronic trading system and the year of the explosion of the warrant market in Spain. Finally, the results also show that the cross-sectional behaviour of overpricing is related to some liquidity patterns. In particular, warrants are more expensive when their bid-ask spreads before transactions are relatively smaller, and also when a larger volume has been traded in the days before the transaction.

5. Price Warrants Comparison

From the previous evidence is already clear that the level of the relative price differences between options and warrants varies with the issuer. Hence, it is reasonable to investigate whether differences in transaction prices of equivalent warrants exist. By equivalent warrants we mean bank-issued options on the same underlying asset, with the same expiration date, same strike price, style and type. These warrants have identical payoff functions but they are not identical products mainly because the issuer

and the size of the contract may not be the same. On the other hand, given that all warrants are traded in the same market, potential differences in prices can not be explained by the actual trading regulations or the microstructure characteristics of the market.

As before, the criteria of matching transaction prices consists on selecting pairs of equivalent warrants with the nearest volume but with no more than one hour between both trades. Data are taken from intraday transactions during 2003. On top of that, we organize the matching sample as pairs of issuers. The final number of observations depends on the two issuers chosen in each case. We find that only three issuers offer a number of price pairs sufficiently representative for carrying out the analysis. They are the issuers identified by numbers 1, 7, and 9 which are, as expected, the three largest issuers in terms of volume. In fact, the trading volume in warrants with similar characteristics and issued by these three institutions represents 60 percent of the total volume of this market. This implies that a significant level of overlapping in products offered by different issuers is observed in this market. The number of observations finally used is 6,496 for pairs with issuers 1 and 7, 12,246 for issuers 1 and 9, and 573 for issuers 7 and 9.

We now compute the relative price difference within each pair of issuers and repeat the analysis performed in Section 4. Table 9 contains the mean and median of the relative price difference for each group of pairs relative to issuers 1 and 7, 9 and 1, and 9 and 7 in panels A, B, and C respectively. All price differences in mean or median are statistically different from zero at 1 percent significance level. The exceptions are the results that are marked with asterisk. As expected, given the results in the previous comparison between warrants and options, call warrants issued by issuer 7 are more expensive than the equivalent warrants issued by institution number 1. Similarly, issuer 9 is also more expensive than issuer 1 for both calls and puts, and call warrants issued by institution 9 are cheaper than equivalent warrants issued by 7. The magnitude of such differences is smaller than in the options-warrants case, but they are important, especially for individual stocks and call options when comparing prices between issuers number 7 and 1. It is surprising to find that issuer number 7 has the cheapest put warrants. It would be interesting to discover the reasons why the same issuer can maintain these high prices for one type of its warrants but not for the other. Finally,

differences between issuers are, generally speaking, larger for call warrants and for warrants on individual stocks.

Since all warrants are traded in the same market, clientele arguments cannot be supported in this case. These differences may be associated with the degree of confidence that investors have on the issuer. In this regard, there is some research that relates the price of warrants with the credit risk of the issuer.[11] However, these three particular issuers are important financial institutions in Spain with similar positions in credit ratings. Credit risk can not be the reason behind these differences in prices.

As before, a multivariate regression may be useful in understanding the relationship between price differences for two equivalent contracts and liquidity, as proxy by the relative spread and/or the relative trading volume. We may expect that warrants with smaller spreads and/or larger volumes present higher prices. The regression, in this case, is given by the following expression,

$$RP_n = \beta_0 + \beta_1 Money_n + \beta_2 TTE_n + \beta_3 RVOL_n + \beta_4 RSP_n + \beta_5 CALL + \beta_6 OPEN + \beta_7 CLOSE + u_n \quad (3)$$

where the explanatory variables are equivalent to the variables used in equation (2).

Table 10 reports the empirical results with respect to each pair of issuers. The p-value of statistical significance is reported below each estimate. In general, we observe that the control variables, moneyness, time to expiration, the dummy for calls and the dummy for the opening of the session, are for most cases statistically significant. However, some of the estimated coefficients present signs contrary to what could be expected. For example, unlike the case of the option-warrant comparison, the price difference in equivalent warrants is larger the closer the time-to-expiration. This finding does not have an immediate interpretation, because the temporal value of options decreases as time goes by, and the investor expectations should reflect this temporal pattern. Moreover, at the beginning of trading, when there is more uncertainty about the future behaviour of the security, the relative price difference is smaller. Finally, the price

[11] See Hull and White (1995), Klein (1999) or Chen (2003) as examples.

difference between calls and puts depends on the pair of issuers considered, and also on the underlying.

With respect to the variables that proxy liquidity, either bid-ask spreads or trading volume, some contradictions are also observed. In this type of market where we find different issuers offering similar products, it seems plausible to expect competition by narrowing spreads. Surprisingly, however, we find that the relative spread is only significant when comparing issuers 9 and 1, and for warrants on individual stocks. On the other hand, the trading volume during the days before the transaction does not seem to be very informative either. Although *RVOL* is a significant variable in all regressions, we find different signs depending on the pair of issuers, and also depending on the underlying analyzed. The R^2 are high, even more than the ones obtained for regressions in Table 8. Unfortunately, however, it is difficult to point out conclusions about the reasons behind the differences observed in prices. This topic deserves further research. Moreover, it should be pointed that the international evidence on this respect is basically inexistent.

These results seem to suggest that in order to explain these price differentials we may want to employ not only economic rational arguments, but also a behavioural reasoning. Given that, generally speaking, investors choose warrants for speculative reasons, it seems that they are not particularly concerned about whether the price is fair or not. What it becomes relevant is the actual over time behaviour of those prices. Note that the issue price for a new contract is exogenously given. In other words, this price is established for the issuer in a completely free decision.

Finally, we match pairs of warrants with the same underlying asset, strike price, and expiration date but, in this case, they are warrants issued by different issuers at different moments of time. When analyzing the precise moment of the issue, we have been able to verify that the more expensive warrant is issued later in the 81 percent of all cases. We think that this fact is important to understand why such differences in prices exit and whether or not they remain during the life of the contracts. Our future research will explore this issue by analyzing the temporal evolution in quotes of pairs of equivalent warrants.

6. Conclusions

This paper provides strong and rather striking empirical evidence in the sense that options with identical or similar characteristics but different price exists side-by-side. We first compare prices of options with different market structures. This is to say, standard options traded in the Derivative Market in Spain (MEFF) and bank-issued options traded in the Stock Exchange Market (*Bolsa de Madrid*). There are two main differences between these markets. On the one hand, the issuer of the warrant is who decide the contract terms and, simultaneously, the offering prices. However, in the official derivative market these two functions are unlinked. Secondly, the liquidity provision is different because, unlike the options market, an electronic limit order book is employed to trade warrants. We exploit these different market structures to test whether differences in prices are actually observed.

As it has been found in other countries, we show that warrants are significantly overpriced with respect to equivalent options, but the difference in prices in Spain is considerably larger than in other markets. We offer some insights that can partially explain this fact. It appears that the creation of warrant markets may serve the speculator investor clientele for which liquidity is more important than a particular given price. We find that a higher relative price difference between warrants and options is positively correlated with the relative bid-ask spread, and negatively correlated with past trading volume. Unfortunately, bid-ask spreads on warrants are only a bit smaller than the corresponding bid-ask spreads for regular options. Thus, our data do not fully support the clientele hypothesis. In addition, our results show that the differences between warrant prices and option prices depend on the warrant issuer. This finding justifies the second analysis in this paper.

When comparing equivalent warrants with different issuers, either market structure or clientele reasons can not be used to explain price differences. The evidence reported shows that warrants with the same characteristics but different issuer present significant divergences in prices. Interestingly, differences in bid-ask spreads or trading volume are not connected with those price differences. Moreover, credit risk associated to the issuer does not appear to be the reason behind the investor decisions when choosing a particular warrant because the three issuers that we compare have similar credit ratings. Our future research will analyze potential explanations of this surprising and new result.

We suspect that the use of quotes instead of transaction prices may provide with alternative explanations. In addition, we should carefully analyze the temporal evolution of our matching pairs to understand the dynamic behaviour of price differentials between alternative issuers.

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Table 1. Market characteristics

This table shows the main characteristics of market design for MEFF(Option) and SIBE(Warrant) structures. Both markets coexist in Spain offering similar products.

	Options	Warrants
Market Regulator	MEFF RV	Sociedad de Bolsas Bolsa de Madrid
Market Supervision	*Comisión Nacional del Mercado de Valores* (CNMV)	CNMV
Liquidity Supply	Quote-driven market	Hybrid market: LOB + Specialist
Order Types	Simple All or nothing Mixed-Combined	Limit Orders "Combinada"
Place	Electronic Market Investor members market	Electronic Market Investor Auth. Co. market
Open Auction	No	No
Close Auction	No	No
Cont. Time	9:00 – 17:35	9:00 – 17:30
Short Sales	Allowed (guarantees are needed)	Not Allowed
Priority Rules	Price-Time Mixed-Simple	Price-Time
Pre-arranged Trades	Among market members	Block Trades (ordinary session) Special Operations (Off-time)
Tick Prices	1 point = 1€ (IBEX) 0.01€ (shares)	0.01€
Price Limits	No	Static Range Dynamic Range
Transparency	Pre-trade: best bid and ask quotes + market depth Post-trade: last price + accumulated volume Actual time Anonymous traders	Pre-trade: 5 best bid and ask quotes + market depth associated Post-trade: last price + last volume Actual time Anonymous traders

Table 2. Security characteristics

This table shows the main products characteristics for MEFF (Option) and SIBE (Warrant) markets. Both markets coexist in Spain trading similar securities.

	Options		Warrants
Underlying Asset	Spanish Equity Options	IBEX35 Mini-Future	No rules (Spsh. and Fgn. Equities Nat. and Intl. Indexes Exchange Rates Interest Rates Commodities)
Size Contract	100 underlying assets	1 underlying asset	No rules (Ratio)
Exercise Style	American	European	No rules (American)
Expiration Date	3rd. Friday March-June-September-December	3rd. Friday Monthly. At least the three nearest	No rules
Last Trading Day	Expiration date	Expiration date	Expiration date or the day before
Introduction of new contracts	One call – One Put The three nearest maturities Five strike prices		No rules
Strike Tick	0.05€ for 0.05-0.95 0.10€ for 1.00-4.90 … 10€ for >200€	100 points if DtM>2 months 50 points if DtM<2 months	No rules

Table 3. Comparing option and warrant markets: Trading volume

The table shows total trading volume (in millions of €) in option and warrant markets during 2003. It distinguishes between the volume traded in call and put options for each market, as well as the underlying. Then, we check for the overlapping level between these two markets. To do this, we analyze trading volume over the same underlying asset, the same expiration date and the same product (in terms of underlying, expiration and strike).

	Options		Warrants	
Total	1043.9		1609.8	
Calls	623.86	59.76%	1028	63.86%
Puts	419.96	40.23%	581.79	36.14%
Individual Stocks	545.59	52.26%	1059.6	65.82%
(underl. no.)	(20)		(27)	
	498.35	47.74%	424.87	26.39%
Market Index	(1)		(1)	
Same Underlying Asset				
All	1043.9	100.00%	1472.3	91.46%
Individual Stocks	545.59	100.00%	1047.5	98.85%
First Five	438.748	80.42%	936.167	88.35%
Same Expiration Date				
All	963.722	92.32%	1423.454	88.42%
Individual Stocks	545.461	100.00%	1014.622	96.86%
Ibex 35 Index Future	418.134	83.90%	408.832	96.23%
Same Underlying, Expiration Date, and Strike Price				
All	234.54	22.47%	1339.6	83.21%
Individual Stocks	152.13	27.89%	932.14	88.99%
Ibex 35 Index Future	82.413	16.54%	407.43	95.90%

Table 4. Equivalent Options and Warrants

This table shows the number of coincidences between contracts in option and warrant markets. We start from the total number of contracts in each market to extract the total number of coincidences. We analyze these coincidences by distinguishing between indivudal stocks and the underlying index, call and put options, and expiration dates.

All underlying assets and option types				
Number of options	Number of warrants	Coincident number of options	Coincident number of warrants	
12490	1684	1007	1278	
		8.06%	75.89%	

Individual Stocks								
	CALLS				PUTS			
	No. Opt	No. War	Coin. O	Coin. W	No. Opt	No. War	Coin. O	Coin. W
21/03/2003	885	96	55	66	885	58	40	42
			6.21%	68.75%			4.52%	72.41%
20/06/2003	798	170	76	98	798	72	46	54
			9.52%	57.65%			5.76%	75.00%
19/09/2003	692	40	0	0	692	17	9	9
			0.00%	0.00%			1.30%	52.94%
19/12/2003	814	281	156	244	814	132	87	129
			19.16%	86.83%			10.69%	97.73%
19/03/2004	682	139	80	96	682	71	49	55
			11.73%	69.06%			7.18%	77.46%
18/06/2004	593	111	70	79	593	50	36	40
			11.80%	71.17%			6.07%	80.00%
17/09/2004	595	98	77	94	595	69	59	69
			12.94%	95.92%			9.92%	100.00%
17/12/2004	325	53	30	32	325	29	19	19
			9.23%	60.38%			5.85%	65.52%
All expirat.	5384	988	544	709	5384	498	345	417
			10.10%	71.76%			6.41%	83.73%

Market Index								
	CALLS				PUTS			
	No. Opt	No. War	Coin. O	Coin. W	No. Opt	No. War	Coin. O	Coin. W
17/01/2003	81	6	0	0	81	4	3	3
			0.00%	0.00%			3.70%	75.00%
21/03/2003	151	12	11	11	151	7	7	7
			7.28%	91.67%			4.64%	100.00%
20/06/2003	141	16	6	8	141	9	7	9
			4.26%	50.00%			4.96%	100.00%
19/09/2003	131	5	0	0	131	3	2	2
			0.00%	0.00%			1.53%	66.67%
19/12/2003	101	24	8	16	101	15	11	15
			7.92%	66.67%			10.89%	100.00%
19/03/2004	127	17	12	16	127	10	7	10
			9.45%	94.12%			5.51%	100.00%
18/06/2004	41	18	9	12	41	10	7	8
			21.95%	66.67%			17.07%	80.00%
17/09/2004	41	13	8	10	41	9	7	9
			19.51%	76.92%			17.07%	100.00%
17/12/2004	47	15	9	12	47	5	4	4
			19.15%	80.00%			8.51%	80.00%
All expirat.	861	126	63	85	861	72	55	67
			7.32%	67.46%			6.39%	93.06%

Table 5. Relative difference in transaction prices between equivalent warrants and options

This table shows the differences in transaction prices over a matched sample of equivalent options and warrants. We use intraday data for options and warrants during the year 2003. P_w and P_o denote warrant and option transaction prices respectively. We compute the mean and median of the price difference and we test whether these differences are significantly different from zero by a t-test and Wilcoxon test, respectively. We also distinguish between call or put options, stocks or market index, and among the different warrant issuers. Panel A provides the statistics for price pairs with no more than one hour distance between transactions; in Panel B the price matching criterion is a maximum distance of 7.5 minutes between transactions; the results in Panel C correspond to the criterion of matching transactions with the closest volume with a time difference of less than one hour. Finally, Panel D contains the results for transaction pairs with the same restriction as in Panel C but now the trading volume in the warrant contract is a multiple of 100 underlying assets. In this last Panel, we are only referring to options on stocks.

Panel A: Maximum distance between transactions 1 hour						
	No. Pairs	$P_W = P_O$	$P_W > P_O$	$P_W < P_O$	Mean	Median
All	12363	192	11629	542	37.49%	25.00%
CALLS	7163	105	6618	440	38.60%	25.00%
PUTS	5200	87	5011	102	35.96%	25.00%
Stocks	6052	158	5453	441	30.39%	19.45%
Market Index	6311	34	6176	101	44.29%	29.31%
Issuer 1	8436	174	7899	363	26.36%	19.05%
Issuer 4	356	8	329	19	20.68%	12.50%
Issuer 5	22	0	22	0	18.67%	17.27%
Issuer 6	273	0	258	15	101.03%	105.13%
Issuer 7	1032	0	1008	24	89.02%	71.43%
Issuer 9	2244	10	2113	121	50.74%	40.97%
Panel B: Maximum distance between transactions 7.5 minutes						
	No. Pairs	$P_W = P_O$	$P_W > P_O$	$P_W < P_O$	Mean	Median
All	4810	87	4537	186	29.73%	19.36%
CALLS	2609	43	2426	140	30.75%	19.23%
PUTS	2201	44	2111	46	28.53%	19.44%
Stocks	2102	65	1902	135	25.04%	15.39%
Market Index	2708	22	2635	51	33.37%	22.64%
Issuer 1	3965	83	3736	146	23.42%	17.26%
Issuer 4	89	1	86	2	18.84%	12.47%
Issuer 5	7	0	7	0	27.56%	22.22%
Issuer 6	83	0	80	3	105.21%	114.29%
Issuer 7	182	0	172	10	94.45%	80.33%
Issuer 9	484	3	456	25	46.19%	40.00%
Panel C: Maximum distance between transactions one hour and closest volume						
	No. Pairs	$P_W = P_O$	$P_W > P_O$	$P_W < P_O$	Mean	Median
All	9135	165	8521	449	33.37%	22.22%
CALL	5203	96	4767	340	33.70%	22.22%
PUT	3932	69	3754	109	32.93%	22.22%
Stocks	4264	128	3783	353	26.73%	16.76%
Ibex	4871	37	4738	96	39.18%	26.54%
Issuer 1	6865	149	6380	336	24.78%	18.42%
Issuer 4	215	4	201	10	20.10%	12.75%
Issuer 5	14	0	14	0	18.57%	18.82%
Issuer 6	198	0	194	4	111.16%	115.38%
Issuer 7	498	1	483	14	89.11%	70.41%
Issuer 9	1345	11	1249	85	47.39%	39.93%
Panel D: One hour, closest volume, and multiples of 100 underlying assets for warrants						
	No. Pairs	$P_W = P_O$	$P_W > P_O$	$P_W < P_O$	Mean	Median
All	3447	120	3075	252	26.59%	17.16%
CALLS	2305	74	2020	211	25.86%	16.67%
PUTS	1142	46	1055	41	28.05%	17.86%
Issuer 1	2675	114	2339	222	20.08%	13.51%
Issuer 4	11	0	8	3	33.87%	40.13%
Issuer 5	14	0	14	0	18.57%	18.82%
Issuer 6	15	0	14	1	116.25%	66.67%
Issuer 7	173	0	166	7	62.23%	56.25%
Issuer 9	559	6	534	19	44.34%	39.13%

Table 6. Relative difference in transaction prices between equivalent warrants and options

This table shows the differences in transaction prices over a matched sample of equivalent options and warrants. We use intraday data for options and warrants during the year 2003. P_w and P_o denote warrant and option transaction prices respectively. We compute the mean and median of the price difference and we test whether these differences are significantly different from zero by a t-test and Wilcoxon test, respectively. We also distinguish between call or put options, stocks or market index, and among the different warrant issuers. We now split trading between buy and sell initiated trades. The transactions are matched following the closest volume criterion with a time difference of less than one hour between the two trades.

Panel A: Buy initiated transactions						
	No. Pairs	$P_W = P_O$	$P_W > P_O$	$P_W < P_O$	Mean	Median
All	5153	83	4812	258	33.96%	22.55%
CALLS	3012	57	2761	194	34.18%	22.41%
PUTS	2141	26	2051	64	33.64%	22.73%
Stocks	2461	67	2192	202	26.88%	17.65%
Market Index	2692	16	2620	56	40.43%	27.12%
Issuer 1	3790	72	3543	175	24.99%	19.16%
Issuer 4	142	1	137	4	21.89%	13.76%
Issuer 5	4	0	4	0	24.79%	25.02%
Issuer 6	94	0	90	4	107.07%	108.37%
Issuer 7	315	0	309	6	91.67%	71.43%
Issuer 9	808	10	729	69	47.20%	40.97%
Panel B: Sell initiated transactions						
	No. Pairs	$P_W = P_O$	$P_W > P_O$	$P_W < P_O$	Mean	Median
All	3982	82	3709	191	32.60%	21.62%
CALLS	2191	39	2006	146	33.03%	21.62%
PUTS	1791	43	1703	45	32.07%	21.62%
Stocks	1803	61	1591	151	26.53%	15.39%
Market Index	2179	21	2118	40	37.62%	25.00%
Issuer 1	3075	77	2837	161	24.52%	17.65%
Issuer 4	73	3	64	6	16.63%	12.18%
Issuer 5	10	0	10	0	16.08%	14.05%
Issuer 6	104	0	104	0	114.86%	120.29%
Issuer 7	183	1	174	8	84.71%	69.23%
Issuer 9	537	1	520	16	47.68%	38.30%

Table 7. Difference in relative spread between equivalent warrants and options

This table shows the differences in relative spreads over a matched sample of equivalent options and warrants. The transactions are matched following the closest volume criterion with a time difference of less than one hour between the two trades. We use intraday data for options and warrants during the year 2003. RSP_w and RSP_o denote warrant and option relative spreads respectively. We compute the mean and median of the difference between the two relative spreads and we test whether these differences are significantly different from zero by a t-test and Wilcoxon test, respectively. Asterisks indicate that the null of mean difference or median difference equal zero is rejected. We also distinguish between call or put options, stocks or market index, and among the different warrant issuers.

	No. Pairs	$RSP_W = RSP_O$	$RSP_W > RSP_O$	$RSP_W < RSP_O$	Mean	Median
All	6781	41	3318	3422	0.0375*	-0.00042*
CALLS	3776	28	1840	1908	0.0558*	-0.00069*
PUTS	3005	13	1478	1514	0.0145*	-0.00033
Stocks	2882	41	1216	1625	0.0553*	-0.00470
Market Index	3899	0	2102	1797	0.0243*	0.00272*
Issuer 1	5502	32	2674	2796	0.0315*	-0.00064*
Issuer 4	135	1	88	46	0.0115	0.01005*
Issuer 5	10	0	3	7	-0.0047	-0.00922
Issuer 6	91	0	35	56	-0.0049	-0.01823*
Issuer 7	261	0	106	155	-0.0177*	-0.01115*
Issuer 9	782	8	412	362	0.1075*	0.00360*

Table 8. Determinants of the relative difference in transaction prices between equivalent warrants and options

This table reports the estimated OLS coefficients from a regression of the relative price difference between equivalent warrants and options on the variables displayed in the first column of the table. P-values are reported in parenthesis. *MONEY* denotes the moneyness degree; *TTE* is the number of days to maturity; *RVOL* is the ratio between the trading volume of options and the matched warrant (in number of underlying assets) during the 15 days preceding the transaction day; *RSP* is the ratio of the relative spread of matching pairs of options to warrants just before transaction represents; *CALL* is a dummy variable for the option type; *OPEN* is a dummy for transactions that take place from 9 to 11; *CLOSE* is a dummy for transactions that take place in the last two hours in the session; D_i records pairs in which the warrant issuer is the number *i*: 1, 4, 6, and 7; *N* indicates the number of observations in each regression. Sample consists of intraday transaction prices of pairs of warrants and options during 2003.

	All	*Stocks*	*Market Index*
Constant	0.4385 (0.00)	0.3647 (0.00)	0.5411 (0.00)
MONEY	-3.1635 (0.00)	-2.5701 (0.00)	-3.5372 (0.00)
TTE	0.0008 (0.00)	0.0011 (0.00)	0.0005 (0.00)
RVOL	-0.0004 (0.00)	-0.0003 (0.17)	-0.0012 (0.00)
RSP	0.0082 (0.00)	0.0244 (0.00)	0.0044 (0.07)
CALL	0.0536 (0.00)	0.0214 (0.06)	0.1024 (0.00)
OPEN	0.0214 (0.02)	0.0022 (0.88)	0.0224 (0.04)
CLOSE	-0.0012 (0.87)	-0.0219 (0.07)	0.0129 (0.13)
D_1	-0.2984 (0.00)	-0.2686 (0.00)	-0.3889 (0.00)
D_4	-0.3691 (0.00)	-0.3554 (0.00)	-0.4534 (0.00)
D_6	0.5294 (0.00)	1.1853 (0.00)	0.3620 (0.00)
D_7	0.3423 (0.00)	0.1027 (0.00)	0.4659 (0.00)
N	6781	2882	3899
R^2	45%	37%	57%

Table 9. Relative difference in transaction prices between equivalent warrants

This table shows the differences in transaction prices over a matched sample of equivalent warrants from different issuers. We use 2003 intraday data to obtain our matched sample. P_{wi} denotes i-warrant transaction price, while P_{wj} is the j-warrant transaction price. We compute the mean and median of the difference and we test whether these differences are significantly different from zero by a t-test and Wilcoxon test, respectively. We also distinguish between call or put options and stocks or market index. Panels A, B and C show price comparison between the different selected issuers.

Panel A: Issuer *i* – Issuer *j* (*i*=7, *j*=1)						
	No. Pairs	$P_{Wi} = P_{Wj}$	$P_{Wi} > P_{Wj}$	$P_{Wi} < P_{Wj}$	Mean	Median
All	6496	176	3920	2400	17.58%	6.87%
CALLS	3177	55	2972	150	32.11%	26.58%
PUTS	3319	121	948	2250	3.67%	-3.03%
Stocks	1340	29	1253	58	31.30%	27.59%
Market Index	5156	147	2667	2342	14.02%	1.08%
Panel B: Issuer *i* – Issuer *j* (*i*=9, *j*=1)						
	No. Pairs	$P_{Wi} = P_{Wj}$	$P_{Wi} > P_{Wj}$	$P_{Wi} < P_{Wj}$	Mean	Median
All	12246	254	11451	541	18.44%	16.88%
CALLS	7992	184	7354	454	19.00%	18.37%
PUTS	4254	70	4097	87	17.39%	12.00%
Stocks	7465	212	6830	423	19.59%	17.71%
Market Index	4781	42	4621	118	16.64%	14.94%
Panel C: Issuer *i* – Issuer *j* (*i*=9, *j*=7)						
	No. Pairs	$P_{Wi} = P_{Wj}$	$P_{Wi} > P_{Wj}$	$P_{Wi} < P_{Wj}$	Mean	Median
All	573	18	202	353	-5.47%	-7.41%
CALLS	305	9	53	243	-9.60%	-10.94%
PUTS	268	9	149	110	-0.78%*	3.57%*
Stocks	306	6	51	249	-9.82%	-10.87%
Market Index	267	12	151	104	-0.50%*	4.76%*

Table 10. Determinants of the relative difference in transaction prices between equivalent warrants

This table reports the estimated OLS coefficients from a regression of the relative price difference between equivalent warrants issued by a different entity on the variables displayed in the first column of the table. P-values are reported in parenthesis. *MONEY* denotes the moneyness degree; *TTE* is the number of days to maturity; *RVOL* is the ratio between the trading volume of options and the matched warrant (in number of underlying assets) during the 15 days preceding the transaction day; *RSP* represents the ratio of the relative spread of matching pairs of options to warrants just before transaction; *CALL* is a dummy variable for the option type; *OPEN* is a dummy for transactions that take place from 9 to 11; *CLOSE* is a dummy for transactions that take place in the last two hours in the session; *N* indicates the number of observations in each regression. Sample consists of intraday transaction prices of pairs of warrants and options during 2003.

	Issuer 7 – Issuer 1			*Issuer 9 – Issuer 1*			*Issuer 9 – Issuer 7*		
	All	*Stocks*	*Market Index*	*All*	*Stocks*	*Market Index*	*All*	*Stocks*	*Market Index*
Constant	0.6861	0.5003	0.8094	0.3123	0.3217	0.2490	-0.7653	-0.5371	-1.3006
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
MONEY	-1.0055	-2.2603	-0.5498	-0.9618	-0.8662	-1.2497	0.6806	0.5310	1.0203
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
TTE	-0.0024	-0.0014	-0.0028	-0.0006	-0.0008	-0.0003	0.0003	-0.0001	0.0013
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.13)	(0.00)
RVOL	-1.9E-5	-0.0004	-1.8E-5	0.0003	0.0011	-0.0001	0.0290	0.0591	-0.0060
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.14)
RSP	0.0005	-0.0005	0.0010	0.0005	0.0009	-2.8E-5	0.0062	0.0085	0.0000
	(0.33)	(0.48)	(0.17)	(0.00)	(0.00)	(0.87)	(0.18)	(0.53)	(0.99)
CALL	0.1370	0.1911	0.1262	-0.0109	-0.0059	0.0387	-0.0759	-0.0986	0.0272
	(0.00)	(0.00)	(0.00)	(0.00)	(0.14)	(0.00)	(0.00)	(0.00)	(0.05)
OPEN	-0.0234	0.0082	-0.0332	-0.0215	-0.0237	-0.0081	-0.0204	-0.0162	-0.0051
	(0.00)	(0.58)	(0.00)	(0.00)	(0.00)	(0.02)	(0.09)	(0.25)	(0.71)
CLOSE	0.0014	-0.0005	-0.0020	-0.0213	-0.0269	-0.0117	-0.0242	-0.0090	-0.0255
	(0.83)	(0.97)	(0.77)	(0.00)	(0.00)	(0.00)	(0.04)	(0.50)	(0.06)
N	5126	1033	4093	9540	5636	3904	411	228	183
R^2	56%	53%	59%	35%	34%	53%	41%	35%	72%

Figure 1. Traded contracts

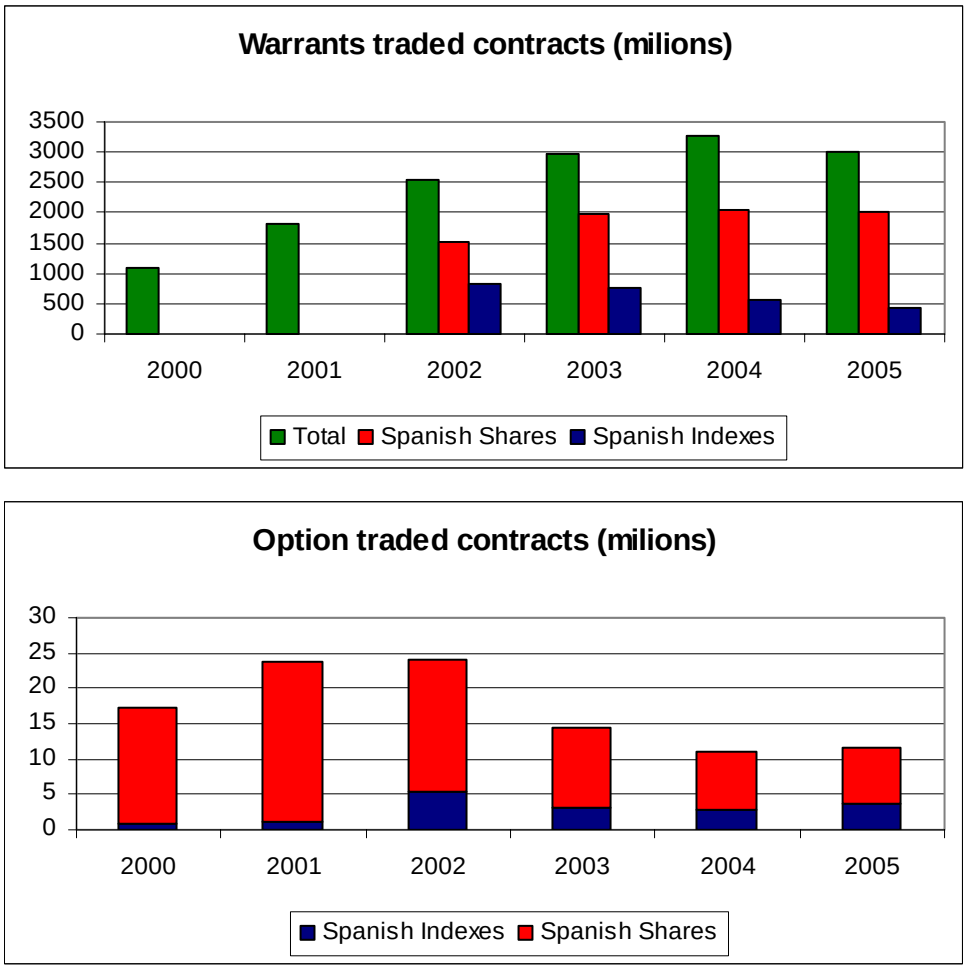

Figure 2. Price pairs distribution

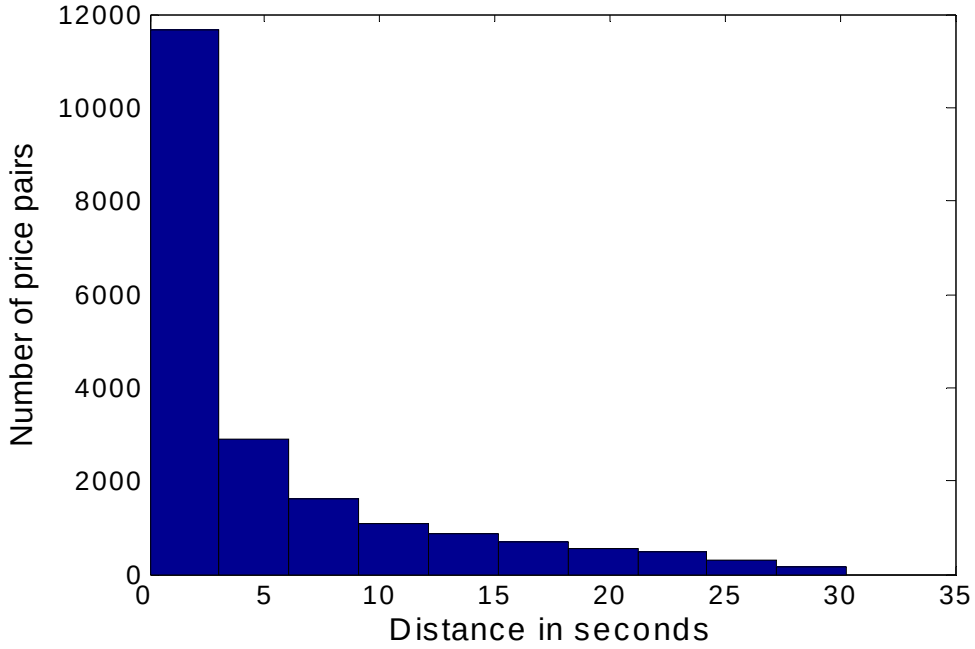

Figure 3. Time Horizon and Moneyness of Transaction Pairs