Regulation and the Demand for Credit Default Swaps in Experimental Bond Markets*

Matthias Weber† John Duffy‡ Arthur Schram§

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Abstract

Credit default swaps (CDS) played an important role in the financial crisis of 2008 leading to calls for regulation. Here, we seek to understand the impact of CDS regulation using a controlled laboratory experiment analyzing CDS pricing in a bond market subject to default risk. Our results show that the regulation achieves the goal of increasing the use of CDS for hedging purposes while reducing the use of CDS for speculation. This success does not come at the expense of lower initial public offering (IPO) prices for the bonds or worse pricing of bonds or CDS in the secondary market.

JEL classification: C92; G40; D53.

Keywords: Experimental finance; asset market experiment; CDS; financial regulation.

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†School of Finance, University of St. Gallen and Swiss Finance Institute. Email: matthias.weber@unisg.ch.

‡Department of Economics, University of California, Irvine. Email: duffy@uci.edu.

§Amsterdam School of Economics, University of Amsterdam. Email: schram@uva.nl.

1 Introduction

Credit default swaps (CDS) are by far the most common and arguably the most important credit derivative contracts. They allow for the hedging of risky investments, such as in bonds that are subject to default risk or subprime mortgage loans. The seller of a CDS (typically a bank or insurance company) provides insurance to the buyer (typically a pension or hedge fund) against the possibility of such a default. In exchange, the buyer pays fees to the CDS seller. CDS can also be used, however, for speculative purposes as is alleged to have occurred prior to the financial crisis of 2008. Indeed, in 2007, the notional value of CDS worldwide peaked at US$61.2 trillion and has steadily fallen ever since to $9.35 trillion as of the end of 2017 (Aldasoro and Ehlers, 2018). Such an incredibly high volume suggests that aside from insurance motives, speculation played a role in the demand for CDS. Indeed, speculation in credit default swaps covering mortgage-backed securities in particular are thought to have played a role in the financial crisis. More generally, CDS were often traded in unregulated markets where buyers had no relationships to the underlying assets and were unable to assess risks. While our interest lies in the role of speculation on the demand side of the CDS market, another major risk lies on the supply side. An important concern for policymakers was that CDS sellers might not have sufficient collateral to cover CDS obligations in case a bond issuer would default. In fact, the latter occurred when Lehman Brothers declared bankruptcy and a major supplier (the American Insurance Group, AIG) was unable to cover its CDS contracts and was bailed out by the Federal Reserve. The problems on the supply side are connected to actions on the demand side: the opportunity for CDS sellers to take on excessive risk depends on the existence of high speculative demand on the buyers' side, in excess of the demand for hedging purposes.

When the financial crisis subsequently gave rise to the European sovereign debt crisis the (potential) regulation of CDS became highly discussed (Ayadi and Behr, 2009, Morgan, 2009, Stulz, 2010, Delatte et al., 2012, Juurikkala, 2012, Augustin et al., 2014). Which role CDS will play during the current crises caused by Covid-19 and the war in Ukraine, and in their aftermath, remains to be seen. The consequences of these crises, including those on government debt, can only be fully assessed in a few years, but the recent increase in bond issuance suggests that CDS may again play an important role.

The possibility to hedge risks using credit default swaps is generally considered to be desirable and the main reason that CDS exist. Speculation with credit default swaps, however, is viewed with a more critical eye as there are a variety of ways in which such speculation might be harmful. For example, speculation with credit default swaps can lead to moral hazard problems if the speculating CDS buyers can influence the underlying value of the asset covered by the CDS.

The regulation of the CDS market is thus a relevant policy issue and some regulatory efforts have been made in the aftermath of the financial crisis. In particular, the G-20 agreed to reforms at their August 2009 meeting that were subsequently codified in the United States in the Dodd-Frank legislation (Carlson and Jacobson, 2014). These reforms were mainly aimed at improving transparency and avoiding excessive accumulation of risk by a single CDS issuer (as, e.g., AIG). Other, more substantive reforms have been proposed but not yet implemented in the United States. The regulation that we focus on here is regulation to insure that credit default swaps are primarily used for hedging purposes, as opposed to speculative motives, for example by restricting CDS purchases to those investors who are exposed to the underlying default risk (as, e.g., discussed in McIlroy, 2010). Germany was the first major country to ban naked credit default swaps in 2010, and this ban was adopted by the rest of the EU in 2011, for CDS related to sovereign bonds. By contrast, the U.S. opted not to ban naked CDS positions in favor of industry-led steering of sales through centralized clearinghouses. Thus, there remains a difference of opinion as to whether bans on naked CDS matter for market liquidity, prices, and the hedging of bond market risk.

Despite various proposals to regulate CDS and some implemented regulations, there is little evidence to date as to whether and how CDS regulation works in practice. Some observers, for example the IMF (2013), acknowledged a lack of evidence on the impact of CDS regulations, but predicted that bans on naked sovereign CDS could "reduce market liquidity to the point that these instruments are less effective as hedges and less useful as indicators of market-implied credit risk." However, the existing theoretical and empirical literature on the effect of naked CDS positions delivers only mixed results. Che and Sethi (2014), argue that naked CDS can be either complements or substitutes to bond (credit) markets improving or reducing liquidity; depending on the environment, multiple equilibria can arise and there may be greater cyclical variations in the cost of debt with naked CDS relative to environments with covered CDS positions. Oehmke and Zawadowski (2017) provide evidence that CDS are held for both hedging and speculative purposes and argue that the primary benefit of CDS is the standardization role that CDS provide; CDS are more common when the underlying bonds are fragmented or have heterogeneous contractual terms that make them difficult to price. Sambalaibat (2022) shows in a dynamic search model with endogenous entry that a ban on naked CDS trading actually reduces bond prices and market liquidity and thereby raises borrowing costs. Similarly, Czech (2020) finds that bond trading volumes (liquidity) are larger when there are CDS for those bonds, and so impairments to liquidity in CDS markets from, say, a ban on naked CDS would likely have some spillover effects on liquidity in the bond market.

Summarizing the state of knowledge about CDS regulations, Stulz (2010) correctly points out that "there is a dearth of serious empirical studies on the social benefits and costs of credit default swaps and other derivatives—not just in the last two years, but in the last several decades." Our study contributes to filling this gap in the literature.[1] Predicting or analyzing the impact of regulations that have not yet or have only recently been implemented with observational field data is inherently difficult and further complicated by the

[1]To the best of our knowledge, there is no previous experimental study of CDS assets or regulation. The financial crisis did, however, spark a recent literature that experimentally studies other types of financial regulation (see Davis and Korenok, 2022, for an excellent overview of this literature).

fact that the introduction of the regulations is usually endogenous and the fundamental values of underlying assets cannot be directly observed. To provide first causal results on the impact of proposed reforms to the CDS market, we thus use a controlled laboratory experiment as a testbed for the analysis of CDS regulation.

Previewing our results, we find that the regulation of CDS that we introduce is indeed successful at increasing CDS usage for hedging purposes. The regulation we consider does not come at the expense of reduced revenue from initial public offerings (IPO) of new bonds. It also does not negatively affect secondary market prices in the bond market, nor in the CDS market. The availability of credit default swaps in general has no decisive influence on bond market prices, neither in the IPO nor in the secondary market; with and without CDS, inexperienced subjects initially underprice the bonds, but with experience they learn to price these bonds very well. The credit default swaps themselves, on the other hand, are substantially *overpriced* regardless of whether or not there is regulation and both by experienced and inexperienced traders alike. The regulation also does not lead to more or less concentration of bond or CDS holdings.

The remainder of the paper is organized as follows. The next section discusses related literature. Section 3 presents the models underlying the experiment, the experimental design, and the procedures. Section 4 describes the results, and Section 5 concludes.

2 Related Literature

There is a large empirical literature examining the pricing of CDS (see Augustin et al., 2014, 2016, for recent surveys). Much of this empirical literature relies on reduced form, no-arbitrage models, as developed e.g., in Duffie (1999), where the incidence of bond default follows a random process, see, e.g., Longstaff et al. (2005), Chen et al. (2008), and Doshi et al. (2013). This literature suggests that much of the pricing of CDS reflects the default risk of the underlying bonds, although other factors, e.g., the market liquidity of CDS themselves (Bühler and Trapp, 2009) and counter-party risk of default by the CDS protection sellers (Arora et al., 2012) can also affect CDS prices. By contrast, our focus in this paper is on the pricing of CDS, as well as the underlying bonds, under different *regulatory regimes*, a topic that is difficult to investigate in the field since, to date, the CDS market has largely escaped regulation (Juurikkala, 2015).

Indeed, our approach also differs from the empirical literature on CDS pricing in that we examine CDS pricing using controlled laboratory experiments, building upon the rich literature in experimental asset markets.[2] Bossaerts (2009), Noussair and Tucker (2013), Palan (2013), Powell and Shestakova (2016), and Nuzzo and Morone (2017) review this literature. In most experimental asset markets, trading is limited to a single asset, though some experiments allow for trades in multiple assets (Childs and Mestelman, 2006, Kleinlercher et al., 2014, Duffy et al., 2021) and some studies allow subjects to trade derivative assets (futures, options) on the principal asset of the market (e.g., Forsythe et al., 1982, Friedman et al., 1983, Forsythe et al., 1984, Friedman et al., 1984, Porter and Smith, 1995, De Jong et al., 2006, Palan, 2010). The experiments reported on in this paper build upon an earlier experiment testing the pricing of bonds subject to default risk (Weber et al., 2018). Relative to that experiment, the present paper adds a new market for credit default swaps on the risky bonds, and considers cases where CDS purchases are regulated or not regulated. We are not aware of any experimental literature investigating credit default swaps or, more generally, credit market derivative assets.

Further, there has been experimental work analyzing proposed financial regulations in the wake of the Great Recession. Armantier et al. (2013), for instance, explore auction design for the US Treasury's disposal of troubled assets. Fischbacher et al. (2013) investigate the effects of reserve requirements on asset prices. Davis et al. (2014) analyze different mech-

[2] For relatively recent studies, see Cheung and Palan (2012), Kirchler et al. (2012), Sutter et al. (2012), Huber and Kirchler (2012), Cheung et al. (2014), Füllbrunn et al. (2014), Noussair et al. (2016), Akiyama et al. (2017), Bao et al. (2017), Holt et al. (2017), Bosch-Rosa et al. (2018), Hanaki et al. (2018), Crockett et al. (2019), Füllbrunn et al. (2020), Huber et al. (2020), Weitzel et al. (2020), Corgnet et al. (2021), Kopányi-Peuker and Weber (2021a), and Kopányi-Peuker and Weber (2021b).

anisms triggering the conversion of contingent capital. Keser et al. (2017) experimentally examine rating agency regulation. Davis et al. (2019) investigate the interaction of liquidity requirements with bank-run experience. Davis et al. (2020) provide an experiment on liquidity regulation in the presence of different types of shocks. Füllbrunn and Neugebauer (2020) analyze the effect of regulating margin purchases. For a review of this strand of literature, see Davis and Korenok (2022). None of the papers in this literature, however, addresses CDS regulation.

3 Experimental Design

3.1 Modeling of the Bond and CDS Markets

We consider an environment with two markets, a bond market and a CDS market. We first describe our model of the bond market and equilibrium bond prices and we then address the CDS market. The bond market model is taken from Weber et al. (2018); we therefore keep the description of this market short.

3.1.1 Bond Market Model

Each bond has a face value, K, which is paid out to the bond holder if the bond issuer does not default prior to the maturity date in period T. In addition, the bond holder receives a coupon payment of iK in each period so long as the bond issuer has not yet defaulted (i is thus the interest rate). If the bond issuer defaults, the bond holder receives no more coupon payments from the period of default onward and also loses the payment of the face value.[3]

[3]We assume a complete loss of future coupon payments and of the principal repayment for simplicity, the model could easily be adapted to allow for nonzero repayments in case of defaults. Similarly, the model features no outside interest for holding money, which could also be introduced easily.

Before being traded in the secondary market, the bonds are first auctioned off in an IPO. The prices paid in the bond market IPO are of particular importance to the bond issuer as they determine the costs of the fixed-maturity debt issue. Lower IPO prices correspond to higher costs of the debt issue. The higher the costs of debt, the higher the probability that the bond issuer defaults. As a consequence, the fundamental value of the bond is not exogenous but depends on the price achieved in the IPO (this is the main difference between our bond market model and most asset market models employed in the experimental literature).

The IPO of new bonds is conducted using a uniform-price auction in which participants bid on the price of a bond (with maturity date, face value, and coupon payments fixed and known). In the periods following the IPO, the bonds can be traded on a secondary market where prices are determined by supply and demand as long as there is no default and as long as the maturity date has not yet been reached.

In the initial period 0, the IPO is held; the IPO price is the market clearing price in the auction, denoted by p_{ipo}. In periods $1, \ldots, T-1$, bond market participants can trade bonds in the secondary market. They can buy and sell these bonds, provided that they have bonds to sell or funds to buy bonds. The timing within each period, $t = 1, \ldots, T-1$, is as follows:

1. It is determined whether the bond issuer defaults.
2. Conditional on no default having occurred in the current period or earlier, the coupon payment is made.
3. The secondary bond market opens and trades can take place (bond sales are thus ex-coupon).

If the final period T is reached (meaning that no default has occurred in period T or earlier), then no more trading occurs and the final coupon payment is paid out together with the face value.

The probability that a bond issuer defaults is endogenous as it depends on the IPO price. The function mapping IPO prices to default probabilities is monotonically decreasing, because a higher IPO price leads to lower financing costs for the bond issuer. This mapping is modeled here using an exponential function:[4]

$$P_d(p_{ipo}) = m\ exp(-c\ p_{ipo}) + b. \tag{1}$$

P_d here denotes the probability that the bond will default in a given period (conditional on no prior default having occurred). The parameters are assumed to satisfy $0 < b < 1$, $0 < m < 1 - b$, and $c > 0$.[5]

The default probability depends on the IPO price, but remains constant after the IPO. For any given default probability P_d, the fundamental value of the bonds can be calculated for all subsequent periods. The fundamental value of the bond in period t, V_t, is conditional on no default having previously occurred. The fundamental value (at the time of trading) is then the face value multiplied by the probability of receiving this final payment plus the expected value of the remaining coupon payments. With $P_n := 1 - P_d$ denoting the probability of not defaulting, this yields

$$\begin{aligned} V_t &= KP_n^{T-t} + \sum_{m=t+1}^{T} iKP_n^{(m-t)} = KP_n^{T-t} + \sum_{m=1}^{T-t} iKP_n^{m} \\ &\overset{\text{for } P_d > 0}{=} KP_n^{T-t} + iK\left(\frac{1 - P_n^{T-t+1}}{1 - P_n} - 1\right). \end{aligned} \tag{2}$$

The fundamental value of the bond is endogenous as it depends on the IPO price. How-

[4]One can think of this mapping as a *reduced form* representation of the relationship between IPO prices and default probabilities. Weber et al. (2018) also provide a *structural model* wherein a higher IPO price leads to lower default probabilities.

[5]b represents the base risk (which is independent of the IPO price; the default risk is always at least b). m is the maximal bond-price-dependent default probability, that is, the maximally possible increase in the default probability, above the base risk, resulting from the IPO price; $m + b$ is thus the highest possible default probability overall. c determines the curvature of the default probability function (a higher c means that the default probability function approaches the base risk more quickly when the IPO price increases).

ever, it is possible to calculate competitive equilibrium prices for the IPO and to use these to arrive at the equilibrium fundamental values with equation (2). Of course, the actual fundamental value after period 0 is determined by the realized IPO price. While the equilibrium IPO price does not have a simple closed-form solution, the solution can be easily computed numerically.[6]

3.1.2 CDS Market Model

In addition to the bond market, there is also a CDS market. There is a fixed supply of CDS, that is, these credit derivatives are not auctioned off (in the experiment, each participant starts with a fixed number of CDS).[7] Assuming a fixed supply in the CDS market is a natural counterpart to assuming a fixed supply of bonds in the bond market. For this paper, the assumption follows naturally, because the focus is on the decisions of (potential) bond and CDS holders and not on the decisions of the entities that issue bonds or sell protection via credit derivatives. The CDS are structured such that one CDS unit pays the holder the face value of the bond, K, in the event that the bond issuer defaults. If the bond issuer does not default and pays out its final coupon payment and face value, the CDS pays out nothing.[8] That is, a CDS is like a tradable insurance paper, covering the face value of the bond. Of course, it is in general also possible that a CDS is not used with a hedging motive but for speculation purposes instead (e.g., when the CDS holder holds no bonds; such positions are called 'uncovered' or 'naked').

To avoid complication, we adopt a sequential market structure. First, the market for bonds

[6]Details about how to compute the equilibrium can be found in Weber et al. (2018). Depending on the model specification, more than one equilibrium price may arise (e.g., a high-price equilibrium with a low default probability and a low-price equilibrium with a high default probability). As our focus is not on equilibrium selection, we choose a specification for the experiment that yields a unique equilibrium.

[7]Our choice of a fixed supply of CDS is guided by our interest in the effects of regulation on the demand side of the CDS market. As noted in the introduction, another important risk in CDS markets lies on the supply side. Studying this would require endogenizing the supply side of the market.

[8]In principle, the pre-specified payoff in case of default can be any value. However, it is common that this amount is the face value of the bond or the face value minus the value of the defaulted loan (the value of the defaulted loan being zero in our model).

opens and trading takes place. Thereafter, the market for CDS opens and trade in CDS takes place. Period 0 in the CDS market is thus just like any other period, since CDS are not allocated in an IPO but are instead already in place from the beginning. The exact timing of bonds and CDS markets in the regular trading periods $t = 1, ..., T-1$ is:

1. It is determined whether the bond issuer defaults.
2. Conditional on no default having occurred in the current period or earlier, the coupon payment is made.
3. The secondary bond market opens and trade can take place (bond trades are ex-coupon).
4. The CDS market opens and trades can take place.

If no default occurs up to and including period T, then no more trading in bonds or CDS occurs: the bonds pay out the final coupon payment together with the face value, while the CDS become worthless. If a default occurs at some point, the bonds pay no more coupon payments from that period onwards and the face value is lost. However, each CDS pays its holder the bond's face value, K.

Since the fundamental value of the bond is endogenously determined, so too is the fundamental value of the derivative CDS; both fundamental values depend on the IPO price in the bond market, because the default probability in the bond market determines the value of insuring (the face value of) a bond. Given the default probability in the bond market, P_d, (with the same notation of $P_n := 1 - P_d$ as above), the value of a CDS can easily be calculated. The fundamental value, W_t, of a CDS in period t (at the moment when this CDS is traded on the market) is the face value of the bond times the probability of a default in the bond market happening after period t. This fundamental value is conditional on no previous default having occurred (otherwise the CDS pays out K with certainty).

$$W_t = K \cdot (1 - P_n^{T-t}). \tag{3}$$

3.2 Treatments

Our experiment consists of three main treatments. We conduct two treatments in which both bonds and CDS are traded; in one of these treatments, bonds and CDS can be traded without restrictions (the unregulated treatment, *FREE*) and in another treatment, CDS are regulated (treatment *REG*). In addition, we compare these two treatments to a control treatment in which only bonds and no credit default swaps are traded. The data from this control treatment are those reported in Weber et al. (2018). There are eight groups (i.e., markets) in *FREE*, nine groups in *REG*, and eight groups in the *Control* treatment.

Our aim is to analyze the effects of CDS regulation that aims at increasing the fraction of covered positions. We have opted to implement this regulation in treatment *REG* in the following way. (1) Subjects are only allowed to buy credit default swaps if they hold underlying bonds: as one CDS insures one bond, subjects may buy any number of credit default swaps up to the number of bonds that they currently hold. (2) If a default occurs, subjects only receive money for covered positions, naked credit default swaps do not pay out. This is a natural way of modeling the regulation as it enforces a hedging motive at two natural time points, when buying a swap and when redeeming it for payment. Both parts can be enforced by regulators.[9]

Equilibrium fundamental values in the bond market are identical in all three treatments. Equilibrium fundamental values in the CDS markets are equal in the two treatments with credit default swaps (the equilibrium fundamental values are discussed in the following section).

[9]Note that such regulation does not require the authorities to have perfect information about all investors' bond and CDS holdings at all time points. Enforcement is also possible if regulators can check the holdings of investors sometimes (comparable to a train conductor checking tickets). An easy way for a partial implementation of the second point would be only allowing credit default swaps with physical settlement (as opposed to those with cash settlement, where the underlying bond does not need to be delivered by the CDS holder for payout).

3.3 Experimental Implementation

Our experimental implementation does not aim at mirroring the exact market microstructure of bond and CDS trading in a particular real-world market (the key advantage of the laboratory is not the realism of the setting but the high level of control). Instead, our aim is to remain with well-understood trading mechanisms, which are identical for bonds and CDS markets (and similar for the bond IPO) and which keep complexity for subjects limited. We therefore opt for double-sided call mechanisms for both markets (and a similar one-sided call market auction mechanism for the bond IPO). This implementation also has the advantage that it leads to one single market price for each trading period. Whether variations of market microstructure details lead to results that are different from the results in our paper may be analyzed in later papers.[10]

The experimental instructions and comprehension test questions can be found in Appendices A to C. Subjects are randomized into groups (markets) of six at the beginning of the experiment. The group composition remains constant over the course of the experiment.[11]

Each group participates in four rounds of multiple periods (period 0, followed by nine regular trading periods, and the final period 10 in which no more trade occurs). Except for the experience that subjects gain by trading, these rounds are identical (that is, all parameters are identical, subjects start with the same endowments, etc.). At the end of the fourth round, one round is randomly chosen for payment. Subjects' points earned from

[10]Various different mechanisms are used for bond IPOs and for bond and CDS trading (see, e.g., Brenner et al., 2009; Biais and Green, 2019). A real-world market with similar features to our implementation is the Israeli corporate bond market, where bond IPOs use a uniform price auction mechanism and the secondary market trading takes place at the Tel Aviv Stock Exchange (Abudy and Wohl, 2018).

[11]The advantage of smaller groups is that (for a given budget) data from more groups can be collected, which facilitates conclusions based on statistical significance. Potential disadvantages from small groups are that markets are thinner (Bossaerts and Plott, 2002) and that (if groups become too small) subjects may not act as price takers. Six subjects seem enough to assume that subjects act as price takers (in line with experimental literature showing that subjects in groups of four or more subjects behave as subjects in large groups; Huck et al., 2004). Not choosing a larger number of subjects per group (e.g., between ten and 20 subjects) reflects that we would only consider the thinness of the markets as problematic if it interacted with the treatment, which we consider unlikely (levels of prices in the experiment do not carry over to the world outside the laboratory anyways, it is the direction of treatment effects that is of primary interest).

the chosen round were exchanged into euros at a fixed and known rate of 1000 points = 1 euro.

The timing in the experiment is precisely as in the model in Section 3.1.2. Markets begin in period 0 with the IPO of bonds. The total number of bonds is 25. In period 0, after the IPO has been completed, subjects can trade credit default swaps with each other. Credit default swaps are already in place at the beginning of each round, with each subject holding two.[12] Each of periods 1 to 10 start with a determination of whether a default occurs; given the IPO price, there is an associated default probability and if the random number drawn for each period (from a uniform distribution on $[0,1]$) is less than or equal to this default probability, then a default occurs and otherwise there is no default. However, whether or not a default occurs is not immediately communicated to subjects. Instead, we adopt the block random termination design of Fréchette and Yuksel (2017), in which we record data for all periods 1 to 10. Subjects' actions in these periods are only payoff relevant if no previous default has occurred (this is communicated very clearly to subjects in the experimental instructions). Next, coupon payments are made. Then, in periods 1 to 9 only, the secondary bond market opens and subjects can trade bonds. Subsequent to bond trading, the credit default swap market opens in which subjects can trade credit default swaps. The tenth period is the final period, in which no more trade occurs (a default at the beginning of period 10 is still possible; if no default occurs, the coupon payment and the face value of the bond are paid out). The credit default swaps only pay out if a default occurs in a round. Subjects are informed about the outcomes of a round immediately after the round ends. More specifically, they are informed about (i) whether a default occurred in any of the 10 periods and if so in which period; (ii) their holdings of cash, bonds, and CDS at the point of default or at the end of the round; and (iii) how many points they

[12]The number of CDS in our experiment is lower than the number of bonds. This choice is conservative in the sense that it makes it relatively difficult for the regulation to be successful, because all CDS could also easily be held for hedging purposes in the treatment without regulation. The larger the number of CDS, the more likely that CDS in the *FREE* treatment are held without covering a bond (this argument can be extended to cases where the number of CDS is endogenously determined, at least in settings in which sellers have the incentive to sell many CDS).

earned in the round.

Subjects have two different accounts, a cash account and an interest account. The money in the cash account can be used for transactions, while the money in the interest account cannot (while it fully counts towards the earnings of a round). Coupon payments go to the interest account while money spent for buying assets or received for selling assets is booked on the cash account. We make this distinction to avoid an inflow of cash during the course of the experiment (for evidence that an inflow of cash can fuel bubbles, see, for instance, Razen et al., 2017).

The parameterization of the bond market follows that in treatment *DEC* in Weber et al. (2018). The face value of the bond is $K = 1000$ and the interest rate is $i = 0.12$. The parameters of the default probability function are $b = 0.02$, $m = 0.6$, and $c = 0.003$. This leads to a unique equilibrium with an equilibrium IPO price in the bond market of 1861 points (rounded to the nearest integer). The equilibrium default probability is about 0.022. The equilibrium price of a CDS in period 0 is 202 points (again rounded to the nearest integer). Figure 1 shows the probability default function in the bond market; it shows that a higher price in the IPO leads to a lower default probability.

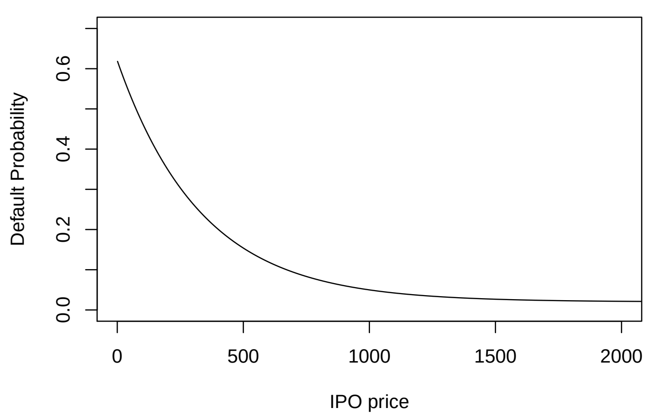

Figure 1: Default Probability Function in the Bond Market

Figure 2 shows the equilibrium fundamental values in the bond and CDS markets. Note that the actual fundamental values in the trading periods are endogenous in both markets as they depend on the (endogenous) probability that the bond issuer will default.

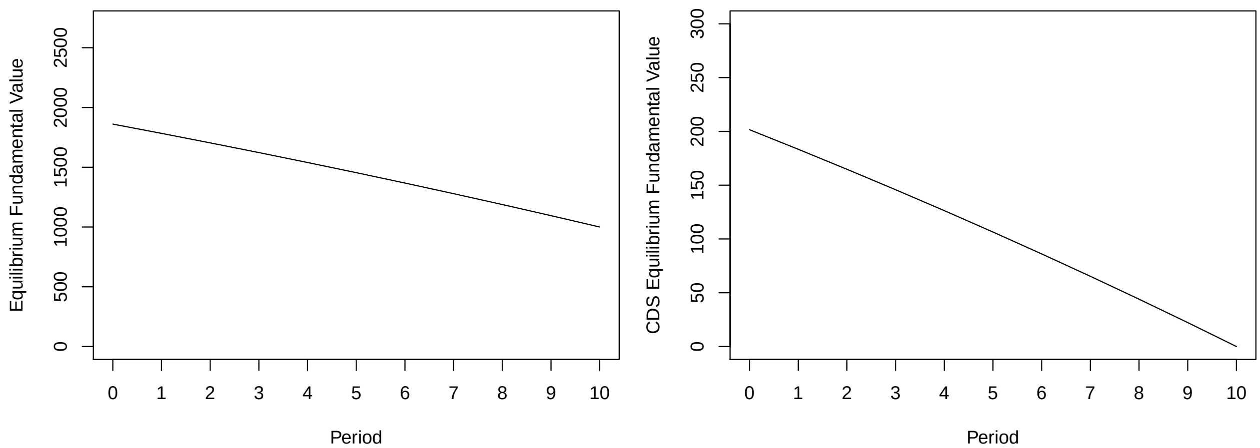

Figure 2: Equilibrium Fundamental Values in Bond and CDS Markets

Notes: The left panel shows the equilibrium fundamental value in the bond markets, the right panel shows the equilibrium fundamental value in the CDS markets.

The endowment that subjects have at the beginning of each round in their cash account is 20650 points in the treatments with CDS and 20000 points in the control treatment. In the CDS treatments, subjects in addition start out with two CDS each. The total number of CDS in a market is thus 12 and is lower than the number of bonds, which is 25. Because we have fewer CDS than bonds, not all bond holdings can be insured. As a consequence, even in the regulated treatment there are always some subjects holding bonds who are allowed to bid for CDS. The monetary endowment is chosen such that the ratio of total means to assets at the equilibrium price is equal across treatments.[13] The framing of the two types of assets is neutral. That is, the terms "bonds" and "credit default swaps" are not used.

[13] In the control treatment, the endowment is 20000 points. At the beginning of a round, there are thus 120000 points in total. The ratio of means to available assets (in equilibrium) is then $120000/(25 \cdot 1861) \approx 2.6$. In the CDS treatments, the means consist of the endowment in points ($6 \cdot 20650 = 123900$) and in credit default swaps (12 in total). The available assets now include bonds and CDS. The corresponding ratio is $(123900 + 12 \cdot 202)/(25 \cdot 1861 + 12 \cdot 202) \approx 2.6$.

Instead, the assets are referred to as Asset A (bonds) and Asset B (credit default swaps).

We use a one-sided call market auction mechanism in the bond IPO and a two-sided call market for trading outside of the IPO for both bonds and credit default swaps (keeping mechanism and interface as similar as possible in the bond IPO and secondary markets for bonds and CDS).[14] In the bond IPO, each subject submits a full demand schedule, that is, subjects specify for self-chosen prices how many bonds they would like to buy at those prices. The computer then constructs an aggregate demand curve from these individual demand curves. The IPO price is determined by the price at the intersection of this aggregate demand curve with the vertical supply curve (as the number of bonds is fixed at 25). Thus, the IPO price is the highest market price for which all 25 bonds can be sold. If more than 25 bonds are demanded at that market price, all bids above that price are successful while it is randomly determined which bids at the market price are rewarded. In the double-sided call markets of trading periods 1–9, subjects simultaneously submit both demand and supply schedules (that is, they can both buy and sell assets). The market price is determined by the intersection of aggregate demand with aggregate supply (in case there is a vertical overlap of aggregate demand and aggregate supply, the midpoint of the corresponding interval is used as market price). If there is excess demand or excess supply at the market price, all bids above or offers below the market price are serviced, while it is randomly determined which bids or offers exactly at the market price are successful. Figure 3 shows the computer interface in the double-sided call market. The interface for the bond IPO is very similar but offers no possibility to enter a supply

[14] While most corporate bonds and CDS are traded in over the counter (OTC) dealer markets, we abstract from dealer intermediation here and for simplicity we use the same call market mechanism for both the IPO and the secondary market. As Duffie (2012) observes, OTC markets are less transparent than centralized market exchanges yet persist due to the out-size profits dealers make from market opaqueness. Attanasi et al. (2016) confirm experimentally, that efficiency and prices are lower in OTC markets as compared with centralized auction markets. Further, there are examples where IPOs and secondary trading of corporate bonds occur in a manner similar to our design, namely the Tel Aviv Stock Exchange (TASE) where IPOs of corporate bonds are conducted using a uniform auction mechanism and the secondary market is conducted on the TASE (though only the opening is a call market), see Abudy and Wohl (2018) for details. The call market mechanism that we adopt is known to be about as efficient as a continuous double auction mechanism for the pricing of assets (see Friedman, 1993) and has other advantages, namely that it is easier to explain and generates a single market price.

schedule.

Figure 3: Interface for Entering Bids and Offers in the Double-Sided Call Market

In addition to the interface shown in Figure 3, subjects always see which round and period they are in, how many points they have in their cash account, how many points they have in their interest account, and how many assets of each type they are holding. Furthermore, they see the market prices in the previous periods of the same round (with a note "no trade occurred" if there was no market price in a period). Bids and offers that cannot be executed are inadmissible (bids for more assets than there are, bids at prices that a subject cannot afford with the holdings in the cash account, offers of more units of an asset than the subject possesses). Furthermore, subjects cannot trade with themselves (that is, a subject's highest bid must be lower than her lowest offer). If subjects make inadmissible bids or offers, they cannot proceed but receive a warning with an explanation of why their bids or offers are inadmissible. Subsequently, they can adjust their bids and offers.

3.4 Procedures

In total, we report data from 150 subjects. In the new treatments, there are nine groups of six subjects in the regulated treatment (*REG*) and eight groups of six subjects in the unregulated treatment (*FREE*). We combine this with data from eight groups of six in the control treatment (*Control*, which is treatment *DEC* from Weber et al., 2018). The experiment was programmed in PHP/MySQL and conducted in English at the CREED laboratory of the University of Amsterdam. Subjects were recruited from the CREED subject pool. The description in the remainder of this paragraph concerns only the new experimental sessions (the control treatment is similar, details can be found in Weber et al., 2018). Sessions lasted about three hours and the average payment was about 30 euros, including a show-up fee of seven euros. After the experiment, subjects had to fill out a short questionnaire asking for a few demographic variables. Subjects were primarily undergraduate students with an average age of about 22 years. About half of the participants were majoring in economics or business, a bit more than half were female, and about a third were Dutch.[15]

4 Results

In this section, we present the main experimental results. Graphs of prices in all periods and rounds for all groups separately can be found in Appendix D.

Sections 4.2 and 4.3 deal with the pricing of the bonds. While we measure mispricing relative to the risk-neutral benchmark, note that substantial deviations from this benchmark

[15] In a few instances, there were software/browser problems. Three groups had to be removed completely from the analysis (for two groups incorrect values were saved and displayed during the whole experiment; for one group failure happened in period 5 of the first round). Removing these three groups left the 25 groups reported here. For one of these 25 groups, a failure happened after the first period of the last round. We thus have the full IPO-data for this group and also use the data from the regular trading periods in the first three rounds (this is group number 8 in treatment *FREE*).

cannot plausibly be explained by risk aversion in a rational way (expected utility theory with asset integration and 'reasonable' levels of risk aversion).[16]

4.1 CDS Regulation and the Fraction of Covered Positions

As discussed in the introduction, whether CDS are held for hedging or for speculative purposes is of great importance for regulators. The main aim of the CDS regulation is to increase the fraction of covered positions (or equivalently to reduce the fraction of speculative naked positions). While it would be surprising if the regulation we introduce in our *REG* treatment led to a *lower* fraction of covered positions than in the unregulated *FREE* treatment, it is a priori not clear that such regulation should result in an *increased* fraction of covered positions. Bond holders can switch to naked positions in the REG treatment, as when they sell their bonds but not their CDS, and if these CDS were badly mispriced, rising rapidly above fundamental, the extent of such naked positions could grow over time, though this would amount to very risky speculative behavior. If we assume some minimal amount of risk aversion, then both mainstream finance and economic theory would predict no difference between the REG or FREE treatments: in both treatments, all credit default swaps would be held entirely for hedging purposes and would thus be *covered* positions. This is the case because the theory assumes that market prices are correct in the sense that they reflect fundamental values; even a minimal amount of risk aversion would lead to the complete absence of speculative CDS holdings, because the value of a

[16]This can be illustrated with an example. Assume a CARA utility function and that a subject exhibits risk aversion that makes her indifferent between accepting or rejecting a 50-50 gamble of losing 5 euros or winning 20 (in our view, this is a high level of risk aversion). The corresponding coefficient of absolute risk aversion is about 0.1313. Assume for simplicity that the bond default probability is as in the risk-neutral equilibrium. With this risk aversion, the value of a bond in period 9 for a subject holding no assets is about 1093 points as opposed to a risk-neutral fundamental value of 1095. The reasons that the valuation with this utility function are so close to the risk-neutral value is that the default risk is low and that utility is close to linear for small stakes. The value of the joint holding of one bond and one CDS is only minimally below the risk neutral fundamental value of $1095 + 22 = 1117$, such that there are no differences if rounded to full points. This is not surprising as a holder of this combination in period 9 is hardly exposed to any risk, because the CDS covers almost the complete loss in case of default (only the last coupon payment is not covered). For a more general discussion of risk aversion under expected utility theory and why reasonable calibrations cannot explain much risk aversion when the stakes are small as in our experiment, see Rabin (2000).

CDS would always be higher for an individual with a bond that the CDS would cover than for an individual without such a bond.

In our experiment, the regulation of the CDS market is effective. That is, the fraction of covered positions is considerably higher in the regulated treatment than in the unregulated treatment. This is shown in Figure 4 which reports the fraction of swaps used for insurance purposes, that is, the number of covered positions in both CDS treatments.

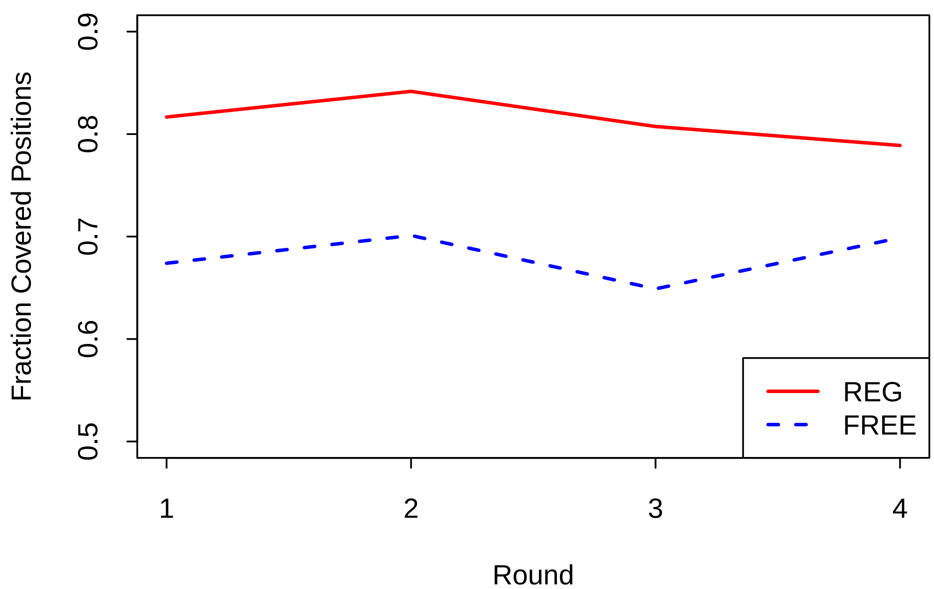

Figure 4: Fraction of Covered CDS Positions

Notes: The graphs shows the fraction of credit default swaps held for insurance purposes. The values are averages across groups.

Figure 4 shows that more CDS positions are covered in treatment *REG* than in treatment *FREE* in all rounds. These differences are on the whole statistically significant. Table 1 summarizes means, medians, and p-values of two-sided Wilcoxon-Mann-Whitney tests.

In sum, the regulation works, with more credit default swaps being used for hedging purposes in the regulated treatment, while more are used for speculative purposes in the

Table 1: Fraction of Covered CDS Positions

	Treatment	Round 1	Round 2	Round 3	Round 4	Mean R1-R4
Mean	*REG*	0.817	0.842	0.807	0.789	0.814
	FREE	0.674	0.701	0.649	0.699	0.681
Median	*REG*	0.850	0.858	0.758	0.833	0.815
	FREE	0.675	0.708	0.592	0.692	0.689
WMW p-value		0.060	0.043	0.020	0.266	0.048

Notes: The upper part of the table shows the means and medians of the fraction of covered CDS positions (across groups; the last column shows mean and median of the mean fraction of covered position per group across rounds). The bottom row shows p-values from two-sided Wilcoxon-Mann-Whitney tests, testing for differences between the treatments (null-hypothesis: no difference). The numbers of observations are 9 (*REG*) and 8 (*FREE*).

unregulated treatment. Though intuitive, this result is *not* a trivial, mechanical result; it reflects the fact that the regulation works. In theory, the regulation could also have been ineffective or even led to the opposite result. In *REG*, uncovered positions can easily occur if CDS holders do not sell their CDS holdings after having sold their bonds. At the same time, in *FREE*, rational risk-averse traders should not buy uncovered CDS if prices are equal to expected payoffs. The situation could have arisen that the regulation deters subjects from being active in the CDS market (for example because of the added complexity in that market or because subjects fear that the buying restrictions would suppress CDS prices so that they do not even attempt to sell their holdings) as predicted by critics of naked CDS bans, thereby leading to a lower fraction of covered positions in the regulated treatment. However, we do not observe such behavior.

4.2 CDS Regulation and IPO Revenues

While the regulation is successful in increasing hedging and decreasing speculation, its effect on IPO prices is a priori unclear. If the costs of financing for bond issuers are increased by the presence of the CDS regulation, then the regulation could potentially yield more harm than good, e.g., leading to a greater likelihood of bond defaults. Such reduced IPO prices in our *REG* treatment could arise if the regulation deters subjects from the markets altogether because they fear the complexity of the CDS regulation or because they are afraid that the regulation renders the CDS market less liquid so that they may not be able to properly hedge their bond holdings. As a benchmark for the IPO pricing, we use the results from our *Control* treatment without any CDS market. As reported in Weber et al. (2018), in the *Control* treatment IPO prices are, on average, below the equilibrium price, considerably so in the first rounds of the experiment, but only very mildly so by the last round. In other words, with experience, traders learn to price the IPO close to the equilibrium price.

Figure 5 shows IPO prices in all treatments, including the *Control*. We observe very similar price development in all treatments. In particular, it seems that the introduction of credit default swaps neither improves nor worsens the pricing of the bonds. Note that the pricing could have been improved, because the introduction of CDS allows traders to hedge risks; the role of risk aversion is then reduced. Comparing the two CDS treatments, we observe that pricing in the treatment with regulation *REG* is very similar to pricing in the *FREE* treatment. The Figure also suggests that there is no difference across the three treatments concerning how fast subjects learn.[17]

In line with the observation from Figure 5, IPO prices are not significantly different across the treatments (not for any of the four rounds, nor for the average across rounds; this holds for Kruskal-Wallis tests, testing differences across all three treatments and for Wilcoxon-Mann-Whitney tests, testing for differences between the two CDS treatments only). Mean and median IPO prices and p-values can be found in Table 2. We conclude that there are no negative side effects from introducing the CDS market or the regulation of that market on the revenues of bond issuers.

[17] In this way, the CDS treatments also provide additional robustness for the findings reported in Weber et al. (2018). That paper shows that underpricing of the IPO in early rounds and learning leading to near-equilibrium prices in the final round, are robust features of the bond market across a variety of different treatments. This paper shows that these findings are even robust to adding additional markets in which credit default swaps are traded, with or without regulation.

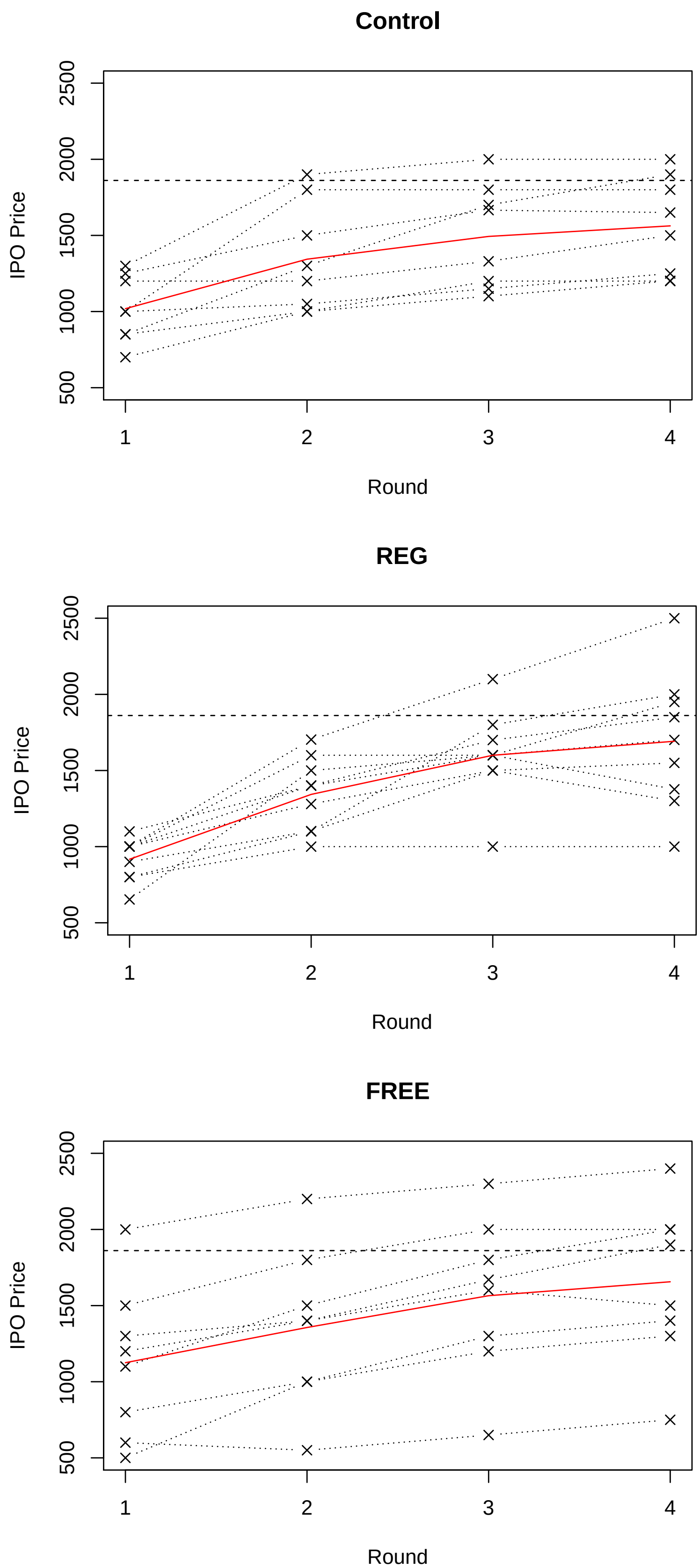

Figure 5: IPO Prices

Table 2: IPO Prices

	Treatment	Round 1	Round 2	Round 3	Round 4	Mean R1-R4
Mean	*Control*	1019	1344	1493	1563	1355
	REG	917	1343	1600	1692	1388
	FREE	1125	1356	1565	1656	1426
Median	*Control*	1000	1250	1498	1575	1373
	REG	1000	1400	1600	1701	1425
	FREE	1150	1400	1635	1700	1496
KW p-value		0.523	0.974	0.880	0.698	0.920
WMW p-value		0.333	0.923	0.961	1.00	0.773

Notes: The upper part of the table shows means and medians of IPO prices (across groups; the last column shows mean and median of mean IPO prices per group across rounds). The second-to-last row shows p-values of Kruskal-Wallis tests, testing for differences across the three treatments (null-hypothesis: no difference). The last row shows p-values of two-sided Wilcoxon-Mann-Whitney tests, testing for differences between the two CDS treatments (null-hypothesis: no difference). The numbers of observations are 8 (*Control*), 9 (*REG*) and 8 (*FREE*).

4.3 CDS Regulation and Prices in the Secondary Markets

We now turn to the pricing of assets across the periods of a round. As a measure of mispricing, the relative absolute deviation (RAD) is a commonly used measure (the measure is introduced in Stöckl et al., 2010, and adapted to allow for periods without trade in Weber et al., 2018). It is defined as

$$RAD = \frac{1}{T^*} \frac{\sum_{\{t|trade\ in\ t\}} |M_t - V_t|}{\bar{V}^*}. \tag{4}$$

In this definition, M_t is the market price in period t, V_t the fundamental value in period t, T^* the number of periods with trade and thus with a market price (we take market prices from periods 0 to $T-1$; that is, in the bond market we include the IPO price together with all secondary market prices, in the CDS market, period 0 is a regular trading period), and $\bar{V}^*$ the average of the fundamental values across the periods with trade.

Figure 6 shows the mean relative absolute deviation in the bond and CDS markets in all treatments. Consider first, the secondary bond markets. We observe only minor differences across the three treatments. As we observed for the IPO prices above, the secondary market bond prices across all periods of a round are similar across all treatments. There is a slight downward trend in the relative absolute deviation, in line with learning in the secondary market. Overall, subjects price the bonds well (especially so in later rounds). Table 3 summarizes the data on the relative absolute deviation and the *p*-values of the statistical tests.[18]

One may have expected that the bonds are priced more accurately in *FREE* than in *REG* or *Control* based on the following argument. In experimental markets, the possibility to engage in short selling has been shown to reduce mispricing (e.g., Haruvy and Noussair, 2006, Weitzel et al., 2020). In our experiment, short selling of bonds is not possible. The introduction of unregulated CDS, however, relaxes the short selling constraint; similarly to short selling of bonds, holding naked CDS allows to exploit mispricing that occurs because of an underestimation of the credit default risk. Nevertheless, our data do not show more accurate pricing of the bonds in *FREE*.

In contrast, credit default swaps are heavily mispriced, on average by a multiple of their fundamental value (the values on RAD together with the fact that the mispricing generally represents overpricing mean that CDS are on average priced at roughly six times the fundamental value in *REG* and more than eight times the fundamental in *FREE*). This mispricing occurs independently of whether there is regulation or not (note that severe mispricing of credit default swaps at a multiple of the estimated fundamental value has also been observed in the field; Singh and Andritzky, 2005). As discussed above, such severe mispricing cannot plausibly be explained by risk-averse rational decisions.

[18] Prices might in general be related to the volume of trade. Trade volume in CDS markets (with average numbers of trades across rounds, groups and periods of 0.54 in *REG* and 0.65 in *FREE*) appear to be thinner than in bond markets (with average numbers of trades of 1.80, 1.53, and 1.29 in *Control*, *REG*, and *FREE*, respectively). Statistical tests for differences across treatments are, however, never significant (when tested with KW tests in bond markets between all treatments or WMW tests between for bonds or CDS between CDS treatments, at significance level 0.05).

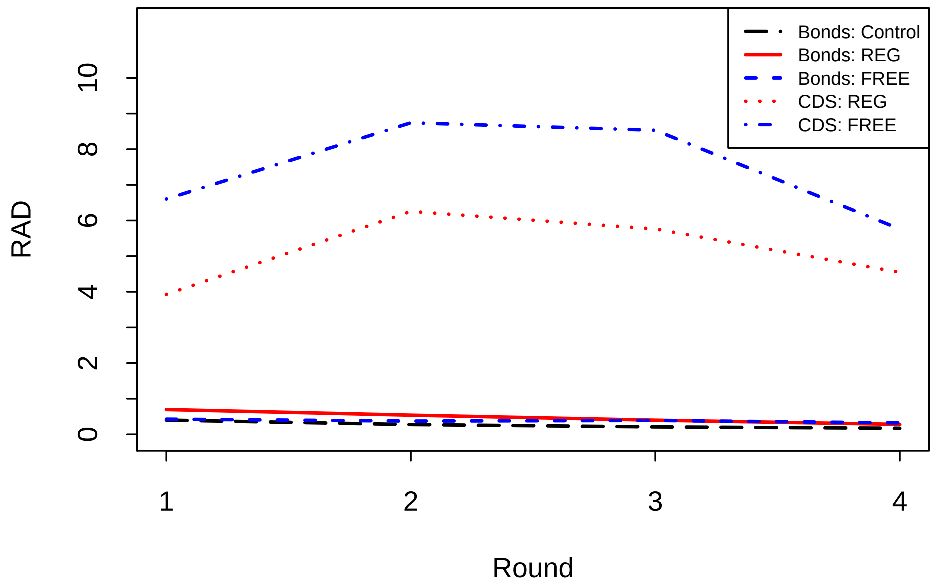

Figure 6: Relative Absolute Deviation of Bond and CDS Markets per Treatment (Averages across Groups)

Table 3: Mean Relative Absolute Deviation

	Treatment	Round 1	Round 2	Round 3	Round 4	Mean R1-R4
Bonds	*Control*	0.40	0.27	0.21	0.17	0.26
	REG	0.70	0.54	0.40	0.28	0.48
	FREE	0.43	0.37	0.39	0.32	0.38
CDS	*REG*	3.93	6.25	5.76	4.55	5.18
	FREE	6.60	8.74	8.53	5.76	7.49
KW p-value Bonds		0.226	0.170	0.179	0.334	0.211
WMW p-value Bonds		0.114	0.277	0.423	0.758	0.423
WMW p-value CDS		0.321	0.673	0.541	0.710	0.481

Notes: The upper parts of the table shows *RAD* in the bond and CDS markets (means across groups; the last column shows the mean of the mean *RAD* per group). The lower parts first show p-values of Kruskal-Wallis tests for differences in the bond market *RAD* between all three treatments and two-sided Wilcoxon-Mann-Whitney tests in the bond markets between the two CDS treatments. The last row shows p-values of two-sided Wilcoxon-Mann-Whitney tests, testing for differences in CDS *RAD* between the two CDS treatments. The null-hypothesis for all tests is that there is no difference between treatments. The numbers of observations are 8 (*Control*), 9 (*REG*) and 8 (*FREE*).

Thus, subjects who rely on credit default swaps to insure their bonds pay an excessively high risk premium for that insurance. Similarly, subjects who speculate with credit default swaps are paying extravagantly high prices in order to do so. The pricing of the swaps looks slightly better in *REG* than in *FREE*, but the differences are not statistically significant. Overall, the evidence on prices in the trading periods suggests that the CDS regulation has no negative impact on the pricing of the assets; (if any, there is a small, positive impact), so that price developments in the CDS markets (and also in the bond markets) do not provide any rationale against the CDS regulation we consider.

4.4 CDS Regulation and the Concentration of Bond and CDS Holdings

Next, we consider the concentration of bond and CDS holdings. From a policy perspective, less concentration of bond and CDS holdings is desirable, as more concentrated holdings are associated with greater systemic risk (e.g., Brunetti et al., 2018). To measure whether very few subjects tend to hold all the bonds and CDS or whether these are distributed relatively evenly across subjects, we use the (normalized) Herfindahl-Hirschman index (*HHI*). This index measures concentration, with zero signifying that a variable is equally distributed among all subjects, while one signifies that a variable is concentrated at one subject with zeros for the other subjects (for asset holdings, a value of zero would be obtained if all subjects held exactly the same number of assets, while a value of one would be obtained if one subject held all assets). The normalized Herfindahl-Hirschman index of a vector of non-negative variables $s = (s_1, ..., s_n)$ is given by

$$H^*(x) = \frac{\left(\sum_{i=1}^n x_i^2\right) - 1/n}{1 - 1/n},$$

with $x = (x_1, ..., x_n) = (s_1 / \sum_{j=1}^n s_j, ..., s_n / \sum_{j=1}^n s_j)$.

Figure 7 shows the normalized Herfindahl-Hirschman index for the different rounds of the experiment. The lines show averages across groups of the *HHI* of subjects' average holdings across the periods of a round, separately for the different treatments and bond and CDS markets.

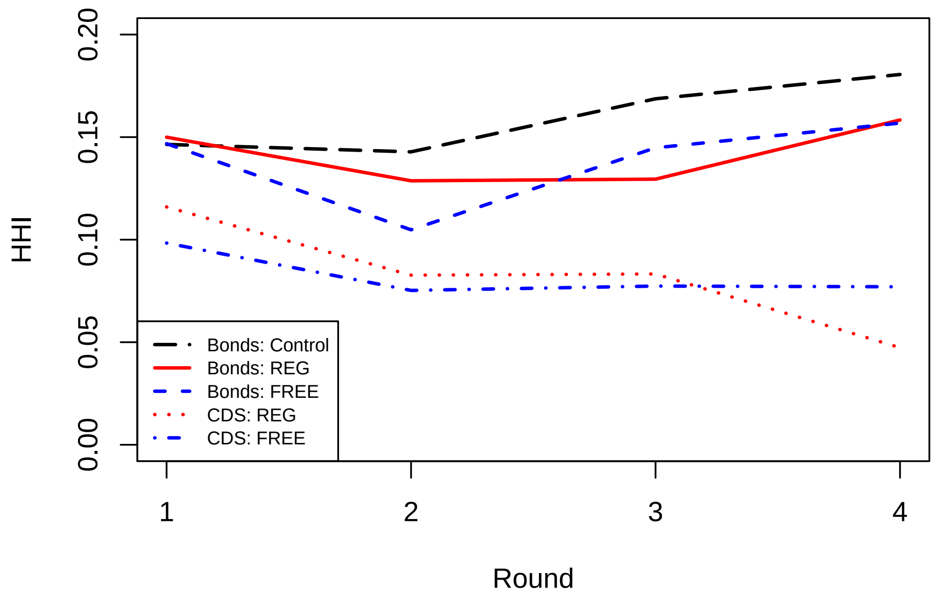

Figure 7: Herfindahl-Hirschman Indices per Round (Averages across Groups)

Turning first to the bond markets, the concentration of holdings in the two treatments with CDS is basically identical. Thus, whether CDS markets are regulated or not seems to have no impact on the distribution of bonds. The concentration of bond holdings in the two treatments with CDS is slightly lower than in the control treatment. This could be driven by the fact that the CDS give an opportunity to insure the bonds, so that also more risk-averse subjects could be willing to hold bonds. Note, however, that risk-aversion in a rational sense cannot explain such a difference (as discussed in Footnote 16) and that the differences are not statistically significant (Table 4 summarizes the data and the *p*-values of the statistical tests).

In the CDS markets, the concentration of holdings is very similar in the two treatments. Only in the fourth round, there is a modest (and statistically insignificant) difference, with

Table 4: Herfindahl-Hirschman Indices per Round (Averages across Groups)

	Treatment	Round 1	Round 2	Round 3	Round 4	Mean R1-R4
Bonds	*Control*	0.15	0.14	0.17	0.18	0.16
	REG	0.15	0.13	0.13	0.16	0.14
	FREE	0.15	0.10	0.14	0.16	0.14
CDS	*REG*	0.12	0.08	0.08	0.05	0.08
	FREE	0.10	0.08	0.08	0.08	0.08
KW p-value Bonds		0. 553	0.713	0.524	0.845	0.809
WMW p-value Bonds		0.541	0.423	0.815	0.758	1.000
WMW p-value CDS		0.743	0.963	0.606	0. 289	0.888

Notes: The upper part of the table shows the *HHI* in the bond and CDS markets (means across groups of the *HHI* of subjects' mean holdings across the periods of a round; the last column shows the mean of these values across rounds 1 to 4). The lower part first shows p-values of Kruskal-Wallis tests in the bond market *HHI* between all three treatments and two-sided Wilcoxon-Mann-Whitney tests in the bond markets between the CDS treatments. The last row shows p-values of two-sided Wilcoxon-Mann-Whitney tests, testing for differences in CDS *HHI* between the two CDS treatments. The null-hypothesis for all tests is that there is no difference between treatments. The numbers of observations are 8 (*Control*), 9 (*REG*) and 8 (*FREE*).

slightly higher concentration of CDS holdings in the unregulated treatment than in the regulated treatment. Overall, CDS holdings are at least not more concentrated in the treatment with regulation. This is intuitive, but it is not self-evident. A fear of not being able to sell CDS when necessary (because the regulation might be binding for those who would like to buy them), for instance, could have led some subjects to shy away from holding CDS entirely, which would have led to a higher concentration of CDS holdings.

5 Concluding Remarks

Credit Default Swaps were long seen as a useful tool to hedge risks in complex markets. Alan Greenspan, former chair of the Federal Reserve of the United States has been quoted to say: "The credit default swap is probably the most important instrument in finance. .... What CDS did is lay-off all the risk of highly leveraged institutions .... on stable American and international institutions" (*Financial Times*, Feb. 8, 2008). The financial crisis that started in 2008 made many start to doubt this point of view. In fact, CDS were often seen as one of the major causes of this crisis. In the *Financial Times* article in which this Greenspan quote appeared, the writer (risk consultant Satayjit Das) concludes that "CDS contracts may not actually improve the overall stability and security of the financial system but actually create additional risks."

Many economists intuitively oppose government regulation that interferes in markets. The idea that markets are efficient and that government intervention causes deadweight losses is widely shared. Yet, some economists supported such intervention in CDS markets in the years after the crisis hit (see Stulz, 2010, for a discussion). This discussion, however, has been hindered by a lack of evidence on how regulation affects CDS markets. Our paper addresses this gap. We use laboratory control to isolate the effects of a widely propagated intervention, a ban on holding CDS for speculative purposes. We investigate the effects of such a policy on the markets concerned.

In our experiment, CDS regulation achieves its purpose. When the regulation is in place, over 81% of CDS held are paired with a holding of the underlying bond. That is, more than 80% of the CDS serve as an insurance against default of the bond to which they are linked. When there is no regulation, this percentage is significantly lower, at just 68%. This successful regulation does not come at the expense of the underlying bond market. Both the IPO market prices and the prices in the secondary bond market remain unaffected by this intervention in the CDS market. Even prices in the CDS market are not negatively affected by this restriction on CDS trades. The regulation also does not affect the concentration of bond holdings; CDS holdings are not more concentrated when the regulation is in place.

CDS regulation is of crucial political and economic importance. Much more research is needed to fully understand the workings of CDS markets and their regulation. An obvious first step mentioned above (in the introduction) is to investigate risks on the supply side of the CDS market. More generally, we believe that theoretical models, empirical work with observational data, and controlled experimental studies all play important roles in this quest. Our first experimental paper on markets with CDS suggests that CDS regulation to decrease speculation can be beneficial without having harmful side effects.

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A Online Appendix: Experimental Instructions for the Regulated Treatment

We reproduce here the full instructions in the regulated treatment *REG*. Differences in instructions between the treatments are discussed in Section C.

Instructions

Welcome to this experiment! Please read these instructions carefully as they explain how you earn money from the decisions that you make. You will be paid privately at the end, after all participants have finished the experiment. On your desk you will find a calculator and scratch paper, which you can use during the experiment.

During the experiment you are not allowed to use your mobile phone or other electronic devices. You are also not allowed to communicate with other participants. If you have a question at any time, please raise your hand and someone will come to your desk.

The experiment consists of four identical rounds. Each round consists of 11 periods, numbered from 0 to 10. Your earnings for each of the four rounds will be in points. **At the end, only your earnings from one randomly chosen round will be paid out to you! The points from the chosen round will be exchanged into euros at the exchange rate 1000 points = 1 euro.** In addition you will receive a show-up fee of 7 euros.

All participants will be randomly divided into groups of 6 people. The group composition will not change during the experiment. You will not know the identity of any group member nor will they know your identity even after the experiment is over. The following describes what you will be doing in each of the four rounds.

Market Setting

You will start the round with an endowment of 20 650 points (your "cash"). During most of the experiment, you will be given an opportunity to trade assets with the other participants in your group (there are two types of assets, assets of type A and assets of type B). In total there are 25 assets of type A and 12 assets of type B. In each period, there will first be a market in which asset A can be traded and after a market in which asset B can be traded.

Holding assets can give you earnings in a way that will be explained below.

If you want to buy some of these assets you can enter the number of assets you want to buy (bid for) at a certain price using the computer interface. You can state as many different bid prices and quantities as you like.

Example (the numbers here provide no indication of what you should enter in the experiment): Imagine that you would like to buy 12 assets if the price per asset is at most 356 points, 7 assets if the price is larger than 356 but no more than 688 points, and only 2 assets if the price is larger than 688 points but no more than 911.5 points. To indicate this, you can enter numbers into the computer interface as follows (if you wanted to enter more numbers you could click on the "show more fields" button):

[Figure 8 appears here in the experimental instructions.]

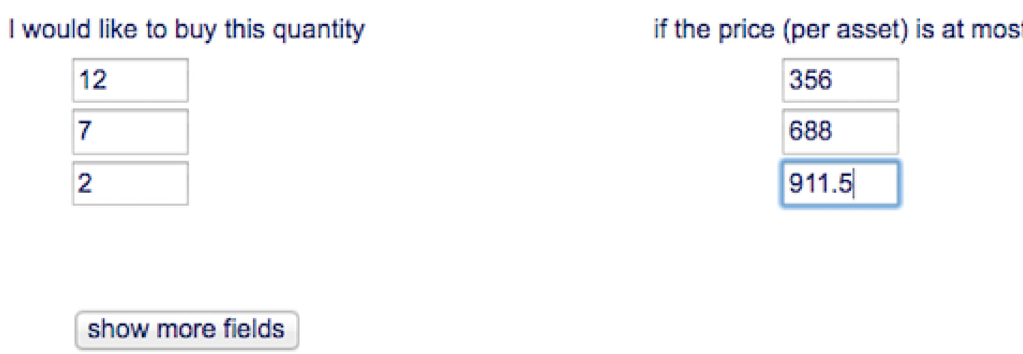

Figure 8: Input fields of the computer interface. [Not labeled in the instructions.]

If the market price turns out to be 600 points, you will then receive 7 assets for 600 points each (thus NOT 2 plus 7, i.e. the quantities that you enter are for the total number you want to buy at a certain price).

If you want to sell assets you previously bought, you can do something similar. You can enter the number of assets that you want to sell (offer quantity) and the offer price that you would like to receive for those units (the interface will be almost identical to the buying example above). You can again enter multiple combinations of quantities and prices.

The bids and offers that you can enter into the computer interface are restricted as follows:

- You can only enter positive integer number as quantities.
- You can only enter positive numbers as prices (if you want to enter a decimal, use a point and not a comma).
- You cannot try to sell more assets than you have at that moment. Similarly, you cannot try to buy more assets than there are available (which is 25 minus the number of assets you have for assets of type A and 12 minus the number of assets you have for assets of type B).
- You cannot enter bids that you would not be able to pay for (with the amount of cash you have).
- You cannot enter multiple bids to buy assets with the same quantity or the same price.
- Similarly you cannot enter multiple offers to sell assets with the same quantity or the same price.
- You cannot try to buy more assets for a higher price than you would want to buy for a lower price (i.e., if you enter for example the quantity 20 with the price 1850, you cannot enter the quantity 10 with the price 1480 in the fields for your bids to buy assets).
- Similarly you cannot try to sell more assets at a lower price than you would sell at a higher price.
- Finally, all of your sell offers must be at a higher price than your bids to buy (i.e. you cannot sell to yourself).

Market Price and Actual Trades

The market price in each period is determined by supply and demand. This means that the price will be chosen that makes the most trades possible. All trades are then carried out at this single market price, which is centrally determined for your group in each period.

Explanation: Imagine you enter that you would like to buy 6 assets if the price is at most 1500 points and one other participant enters that she would like to buy 9 assets if the price is at most 1500. Imagine further that nobody else in the market enters a buying bid at 1500 points or a higher price. This means that *all participants of the market together* would like to buy 15 assets if the price is at most 1500 points per asset. The aggregation of the buy orders can be done for all prices and yields the market demand schedule. This demand schedule contains the information of all buy orders for *all participants of the market together* and can be represented by a step function as below. On the horizontal axis you can see the total quantity demanded for each price on the vertical axis (this is a very simple example and the quantities and numbers provide no indication of what you should enter in the experiment). In the graph of this simple example you can see that all participants of the market together are willing to buy up to 75 assets at a price of 500 points per asset, only 50 assets at a price of 1000 points per asset, and only 15 assets at a price of 1500 points per asset.

[Figure 9 appears here in the experimental instructions.]

A similar schedule can be derived for the supply side of the market, aggregating all the sell offers. When drawn in the same graph, the supply schedule is an increasing step function.

[Figure 10 appears here in the experimental instructions.]

The market price is the price at which the two curves intersect (in this example 1000). Note that at this price, 10 more assets are demanded than supplied (50 assets are demanded

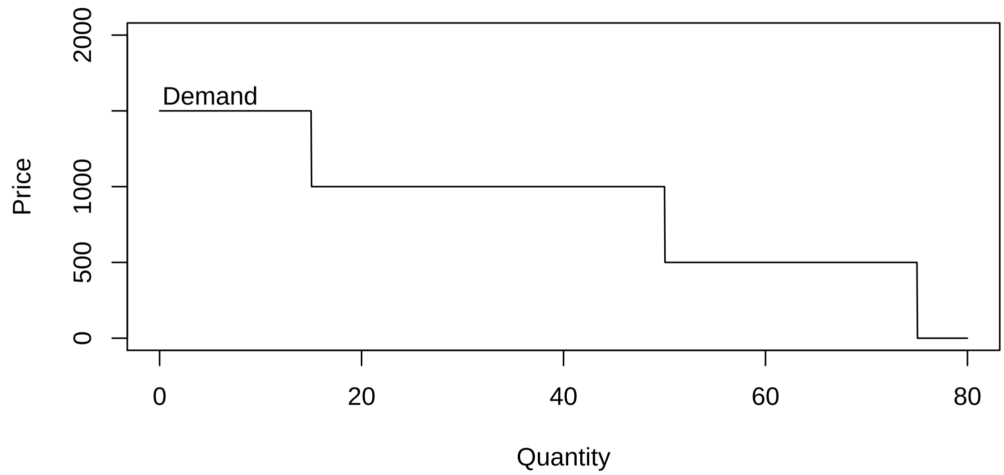

Figure 9: Demand schedule. [Not labeled in the instructions.]

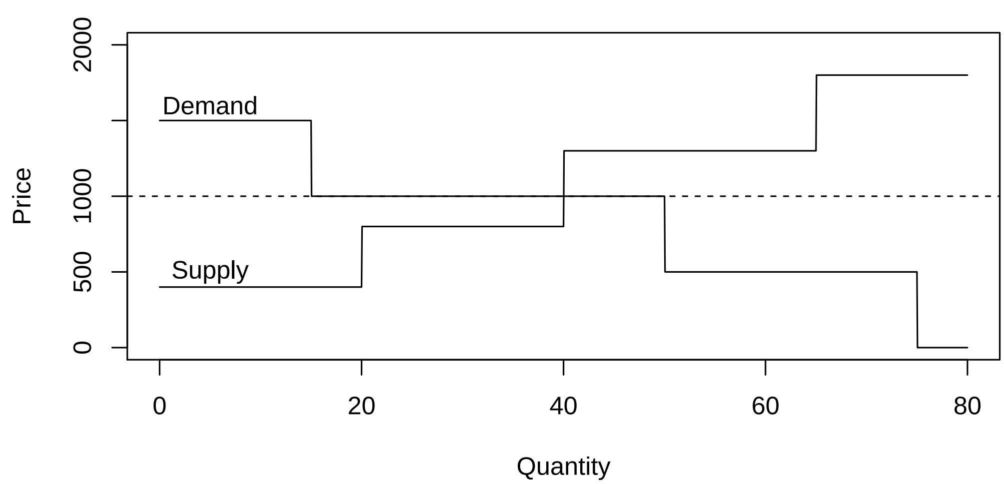

Figure 10: Demand and supply schedules. [Not labeled in the instructions.]

while only 40 are supplied). In this case a random selection of 10 bids *from all the bids at the market price* would not be fulfilled (it is similarly possible that there is more supply at the market price than demand).

In some rare cases there can also be a whole interval of prices at which most trades can be carried out and the demand and supply schedule overlap vertically. In such cases the middle of the interval will be the market price. If no bids or offers are made at all or if all bids to buy are at lower prices than all offers to sell there will be no trade and also no market price.

You will always be told the market price after the trading. You will not be told the total number of trades in the market (except if there are none).

Properties of Asset A

There will be no trading in period 10. If you hold assets of type A in period 10, you will receive 1000 points for each asset, provided that the assets have not defaulted (more on this below).

In each of the periods 1-10 you receive interest payments on your asset A holdings (if they have not defaulted). The interest payment per asset is 12% of the final value (1000 points), which means that you will receive 120 points for each asset A you hold in a period. These earnings will be paid to a separate account – they are part of your earnings for the round, but you cannot use those points to buy more assets.

Asset A has a special property. There is a constant possibility of “default”. At the beginning of each period (from period 1 on to period 10) it is determined whether a default occurs or not. How this probability of default is determined will be explained shortly. If a default occurs, all assets will become completely (!) worthless for all periods remaining in the round. This means that from the period of default onward there will be no interest payments and there will be no payoff of 1000 points per asset after period 10.

Period 0 Trading of Asset A and Probability of Default

The first period of each round is a special period (period 0). In this period, none of the participants holds any of the 25 assets of type A. You can try to buy them as in the regular periods 1,2,...,9, but instead of buying them from other participants you will buy them directly from the experimenter. The computer interface is similar to the computer interface in the regular periods (i.e. you can enter the number of assets you want to buy at a certain price). The experimenter only sells assets in period 0 and does not interfere with the market thereafter. The experimenter will sell all assets in this period, for the highest unique price at which all of them can be sold (if there is not enough demand to sell all assets even at a minimal price, the experimenter will sell as many assets as are demanded).

The outcome of this period 0 is important not only because it distributes the type A assets amongst the participants in the group. It also determines the probability that these assets default in each of the other periods. The higher the market price is in period 0, the lower is the probability that there will be a default (this probability is determined in period 0 and stays constant once period 0 is over). The following graph shows you the exact relationship between period 0 price and default probability. On the horizontal axis you can see possible period 0 prices and on the vertical axis you can see the default probability that would result from each price.

[Figure 11 appears here in the experimental instructions.]

The following short table gives you some period 0 prices and the corresponding default probabilities.

[Table 5 appears here in the experimental instructions.]

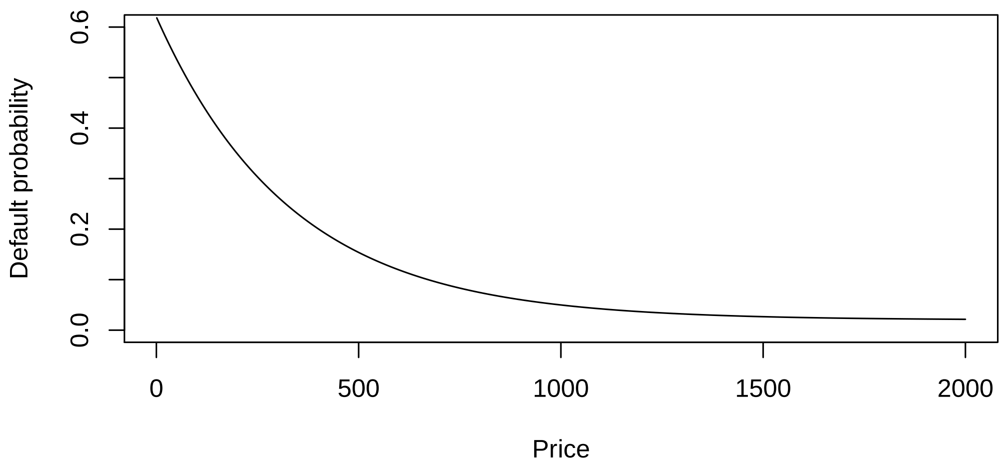

Figure 11: Default probability function. [Not labeled in the instructions.]

Table 5: Values Default Probability Function. [Not labeled in the instructions.]

Price	1	100	200	400	600	800	1000	1500	2000	3000	5000
Prob.	0.618	0.464	0.349	0.201	0.119	0.074	0.050	0.027	0.021	0.020	0.020

At the beginning of each of the regular periods, the computer program determines whether or not there is a default *for the whole market* using the default probability determined by the price in period 0.

Properties of Asset B

In the beginning of a round, each participant has 2 assets of type B. Type B assets are traded in the same way as assets A, but for type B assets period 0 does not play a special role (type B assets are traded in period 0 in the same way as in any of the periods 1,...,9).

Type B assets do not pay any interest and they are not exchanged for points in period 10. However, they become valuable if there is a default of type A assets. If you have type A assets when a default makes them worthless, type B assets you possess may give you points. You will receive 1000 points for each type B asset as long as you hold more type A assets than type B assets or an equal number of both types. If you have more type B assets than type A assets at the time of default you will receive 1000 points times the number of type A assets. You will receive nothing for the remaining type B assets. For example, assume that at the time of default, you hold 4 assets of type A. If you have 2 assets of type B you will receive 2000 points. If you hold 4 assets of type B you will receive 4000 points and if you hold 6 assets of type B you will also receive 4000 points.

There is a special rule for buying type B assets. In any period, you may not buy so many type B assets that you would have more of them than of type A assets. If you have for example 8 assets of type A and 4 assets of type B at a certain point, you can try to buy at most 4 type B assets. This does not mean that you cannot end up having more type B assets than type A assets – you may for example have equally many type A and type B assets at some point and then decide to sell type A assets, which would leave you with more type B assets than type A assets. However, as explained before, the type B assets in excess of type A assets will not pay you 1000 points in case of default of type A.

Information on Defaults

Although it will be determined at the beginning of each period whether there is a default in this period or not, we will not tell you whether or not a default has occurred! You will always continue the experiment as if no default has ever occurred – only after each 11 period round we will tell you if there was a default or not and if so, in which period the (earliest) default occurred. Your earnings for that round are then determined as of the period the default occurred (your earnings are your cash holdings and the points earned in your interest account at the time of default, plus the earnings from your type B assets – your type A assets at the time of default do not affect your earnings in any way). This means that any action you took after the default occurred does not affect your earnings (but when you take the decisions you don't know whether a default had previously occurred).

Summary of the Information

- 4 identical rounds
- 10 regular periods per round

- 20 650 points cash to buy assets per round
- Period 0 is special and the price of type A assets determines the default probability.
- If there is a default all type A assets become completely worthless. Earnings are then based on interest paid before the default, cash holdings at the time of default, and earnings from type B assets.
- If there is a default, you receive 1000 points for each type B asset you have at the time of default if you have at least as many type A assets as type B assets. If you have more type B assets than type A assets you will receive 1000 points times the number of type A assets you have.
- Each type A asset pays 120 points interest per period (if the asset is not in default).
- Points earned on type A assets in the interest account cannot be used to buy assets.
- If there is no default, then in period 10 each type A asset is exchanged for 1000 points. Type B assets are not exchanged for points in period 10.
- You cannot buy so many type B assets that you would have more of them than of type A assets.
- We don't tell you during a round if there is a default, you always continue as if there is none. However, the default is used to determine your round earnings.

B Online Appendix: Comprehension Test Questions in the Regulated Treatment

We reproduce here the test questions in treatment *REG*, with check marks added to indicate correct answers. Differences in test questions between the treatments are discussed in Section C. Note that subjects had to answer all questions on a given screen correctly to proceed to the next screen. If they did not answer all questions correctly and tried to proceed to the next screen, they received the following error message: "You did not answer all questions correctly. Take another look at the instructions or raise your hand if you need help."

B.1 Screen 1

In period 0, the experimenter tries to sell all 25 type A assets. Imagine that all of the other 5 participants in your market enter only one bid each and that all of their bids are equal, specifying a quantity of 2 and a price of 1500. Imagine that you enter the following three bids:

Quantity 4 and Price 2000,

Quantity 8 and Price 900,

Quantity 25 and Price 50.

What will be outcomes of this?

(a) All others receive 2 type A assets each and pay a price of 1500 points per asset. You receive 15 type A assets, some for a higher price than 1500 points, some for a lower price.

(b) All others receive 2 type A assets each and you receive 15 type A assets. Everyone pays 50 points per asset. ✓

(c) All others receive 2 type A assets each and you receive type A 4 assets. Everyone pays 1500 points per asset.

(d) All others receive 2 type A assets each and you receive 25 type A assets. Everyone pays 50 points per asset.

In period 0 in the market for asset A, imagine that 4 of the other 5 participants in your market enter only one bid each and that all of their bids are equal, specifying a quantity of 5 and a price of 800. The fifth other participant and you both enter a quantity of 10 and a price of 600. What will be outcomes of this?

(a) The market price will be 600. The 4 participants that entered the same bids receive 5 type A assets each, you and the person entering the same bid as you will receive 5 type A assets each.

(b) The market price will be 800. The 4 participants that entered the same bids receive 5 type A assets each, you and the person entering the same bid as you will receive 5 type A assets each.

(c) The market price will be 600. The 4 participants that entered the same bids receive 5 type A assets each, you and the person entering the same bid as you will receive 5 type A assets *together* (who receives how many exactly will be determined randomly). ✓

(d) The market price will be 800. The 4 participants that entered the same bids receive 5 type A assets each, you and the person entering the same bid as you will receive 5 type A assets *together* (who receives how many exactly will be determined randomly).

Imagine that you want to buy 25 assets in total if the price is at most 204 points per asset. If the price is larger than 204 points but at most 788 points you want to buy 13 assets in total. If the price is larger than 788 points but at most 1800.5 points you want to buy 8 assets. What do you enter into the corresponding part of the computer interface?

(a) Quantity: 25, Price 204, Quantity 13, Price 788, and Quantity 8, Price 1800.5. ✓

(b) Quantity: 8, Price 1800.5, Quantity 5, Price 788, and Quantity 12, Price 204.

B.2 Screen 2

In periods 1 to 9 you can trade the asset with the other members of your group. You can enter bids to buy assets and offers to sell assets. Imagine that you consider both, buying and selling assets of one type. Which of the following is correct?

(a) You cannot try to buy assets at a higher price than the lowest price at which you are willing to sell assets of the same type. ✓

(b) You can try to bid for as many assets as you like at any price. If the market price turns out to be high, your cash holdings may become negative.

(c) You can make sell offers for the same quantity at different prices.

In the very beginning of each period from period 1 to 10 it will be determined whether there is a default. If there is a default, what happens to the assets of type A?

(a) The assets will not pay any interest anymore for the remaining periods of this round. In the last period they will nevertheless be exchanged into 1000 points per asset.

(b) The asset will not pay any interest anymore for the remaining periods of the round and participants will not receive any points for the assets in the last period. ✓

The default probability depends on the market price of asset A in period 0. Which of the following is NOT correct?

(a) After period 0 has ended, the probability that there is a default is fixed for the rest of the round.

(b) You can see in the corresponding graph in the instructions how the price in period 0 determines the probability of default.

(c) When a new round starts, the default probability in the round before does not matter anymore for the new round.

(d) The default probability for each period is determined in the period before. ✓

Imagine that in period 6 you hold 7 type A assets. Other members of your group each offer to sell 3 units at a price of 1100 and ask to buy 6 units at a price of 1000. You offer to sell 7 units at a price of 1151 and ask to buy 6 units at a price of 1149. What trades are you involved in, in period 6?

(a) You sell 7 units at a price of 1151.
(b) You sell 7 units at a price of 1149.
(c) You sell 7 units at a price of 1100.
(d) You sell 7 units at a price of 1000.
(e) You buy 6 units at a price of 1000.
(f) You buy 6 units at a price of 1100. ✓
(g) You buy 6 units at a price of 1149.
(h) You buy 6 units at a price of 1151.

B.3 Screen 3

If you hold type A assets at some point you may receive interest payments. Which of the following is correct?

(a) You can use the money from your interest account to buy assets in later periods.
(b) For each type A asset you are holding in a period you receive an interest payment of 120 points (if there has been no default before). ✓
(c) A type A asset only pays interest in the period right after you bought it, even if you hold it for multiple periods.

There are rounds and periods in this experiment. Which of the following is correct?

(a) There are 4 rounds in the experiment (each consisting of 10 regular periods and period 0). When you start a new round you have 20650 points in cash, 0 points in your interest account, no assets of type A, and 2 assets of type B. ✓

(b) In each of the regular periods you have 20650 points of cash to buy assets with.

(c) Type A assets only last for one period, once the interest of a type A asset has been paid the asset always loses its value.

In each period there is the possibility of a default that makes all type A assets completely worthless. What happens when such a default occurs?

(a) You will immediately be informed that the default occurs, your earnings are determined and your group will continue straight with the next round.

(b) You will only be informed after the end of the round that this default occurred. Without you knowing it, the further actions you take during the rest of the round will no longer influence your earnings of the round. ✓

B.4 Screen 4

If there is a default, you can earn points with the type B assets you have. Which of the following is correct?

(a) For each type B asset you have at the time of default you receive 1000 points – but only if you have at least as many type A assets as type B assets, otherwise you receive less. ✓

(b) You will only be informed at the end of a round if a default occurred before. The number of type B assets you have after period 10 determine your earnings if a default occurs, also if this default occurs in an earlier period.

(c) You receive interest for each period that you have held a type B asset before the default occurs.

(d) You cannot earn points with type B assets if a default occurs. If no default occurs, each type B asset is exchanged for 1000 points at the end of the round.

You can trade with type B assets. Which of the following is correct?

(a) As in the case of trade with type A assets, also the price of type B assets in period 0 determines the probability of default of the assets.

(b) Each participant has 2 type B assets in the beginning of each round. Type B assets are traded in period 0 exactly in the same way as in periods 1,...,9. ✓

(c) In each period, type B assets are traded before type A assets.

There are some restrictions on buying and selling assets. Which of the following is NOT correct?

(a) You cannot try to buy more assets than there are (at most 25 assets of type A and 12 assets of type B).

(b) You cannot try to sell more assets than you have.

(c) You cannot have more assets of type B than of type A. ✓

(d) You cannot try to buy so many assets of type B that you would have more of them than of type A assets.

Assume that a default occurs in period 5. In that period, you hold 5 assets of type A and 8 assets of type B. In period 10 you hold 9 assets of type A and 9 assets of type B. How much will you receive for your type B assets in this round altogether?

(a) 0 points

(b) 1000 points

(c) 5000 points ✓

(d) 8000 points

(e) 9000 points

C Online Appendix: Differences in Instructions and Test Questions between Treatments

Instructions and test questions are very similar between treatments. Below, the differences between treatments *REG* and *FREE* are detailed. The full instructions and test questions of the control treatment can be found in the online appendix to Weber et al. (2018). In short, the instructions in the control treatment are very similar to the ones reproduced here, without any mention of asset B (and referring to asset A just as the asset).

C.1 Differences in Instructions

The instructions in the unregulated treatment *FREE* are very similar to the reproduced instructions in the regulated treatment *REG*. Only the explanations about the regulations concerning type B assets are left out. To be precise, the instructions are different in the following points:

- The second paragraph under the heading "Properties of Asset B" reads "Type B assets do not pay any interest and they are not exchanged for points in period 10. However, they become valuable if there is a default of type A assets. If there is a default, which makes type A assets worthless, you will receive 1000 points for each type B asset at the time of default.“
- The third paragraph under the heading "Properties of Asset B" in the regulated treatment is removed in the unregulated treatment.
- The sixth bullet point in the summary reads "If there is a default, you receive 1000 points for each type B asset you have at the time of default."
- The second to last bullet point in the regulated treatment is removed in the unregulated treatment.

C.2 Differences in the Comprehension Test Questions

The first three screens of test questions are identical in both treatments. Screen 4 is as follows in the unregulated treatment:

If there is a default, you can earn points with the type B assets you have. Which of the following is correct?

(a) For each type B asset you have at the time of default you receive 1000 points. ✓

(b) You will only be informed at the end of a round if a default occurred before. The number of type B assets you have after period 10 determine your earnings if a default occurs, also if this default occurs in an earlier period.

(c) You receive interest for each period that you have held a type B asset before the default occurs.

(d) You cannot earn points with type B assets if a default occurs. If no default occurs, each type B asset is exchanged for 1000 points at the end of the round.

You can trade with type B assets. Which of the following is correct?

(a) As in the case of trade with type A assets, also the price of type B assets in period 0 determines the probability of default of the assets.

(b) Each participant has 2 type B assets in the beginning of each round. Type B assets are traded in period 0 exactly in the same way as in periods 1,...,9. ✓

(c) In each period, type B assets are traded before type A assets.

There are some restrictions on buying and selling assets. Which of the following is NOT correct?

(a) You cannot try to buy more assets than there are (at most 25 assets of type A and 12 assets of type B).

(b) You cannot try to sell more assets than you have.

(c) You cannot have more assets of type B than of type A. ✓

Assume that a default occurs in period 5. In that period, you hold 5 assets of type A and 8 assets of type B. In period 10 you hold 9 assets of type A and 9 assets of type B. How much will you receive for your type B assets in this round altogether?

(a) 0 points

(b) 5000 points

(c) 8000 points ✓

(d) 9000 points

D Appendix (for Online Publication): Graphs of Prices in all Markets

Figures 1 to 7 show the market prices in the bond markets in all rounds and periods for all groups (Figures 6 and 7 show these graphs of the control treatments without CDS from Weber et al., 2018). Each row corresponds to one group, starting with the first round on the left and ending with the fourth round on the right. Market prices are shown with red circles. Red crosses show the mean of the highest bid and the lowest offer price when no trade is carried out, but when both bids and offers are present. The equilibrium fundamental value is drawn with a solid black line and the price leading to the highest possible expected earnings for all subjects together is drawn with a dashed black line. Furthermore, the actual fundamental value within a round (which depends on the price in the IPO and is different across groups and rounds) is drawn with a dotted blue line. As there is no more trade in the tenth period, periods only reach from 0 (the IPO) to 9. The fourth round of group 8 in *FREE* does not show prices for most periods due to the software failure described in Footnote 15 (in bond and CDS markets).

Figures 8 to 12 similarly show the market prices in the CDS markets. Here, period 0 is just a regular trading period, as there is no IPO of credit default swaps. Equilibrium and actual fundamental value (the latter depending on the IPO price in the bond market) are again drawn with a solid black line and a dotted blue line. There is no black dashed line, as such a similar “collusive equilibrium price” does not exist in the CDS market (as there is no IPO).

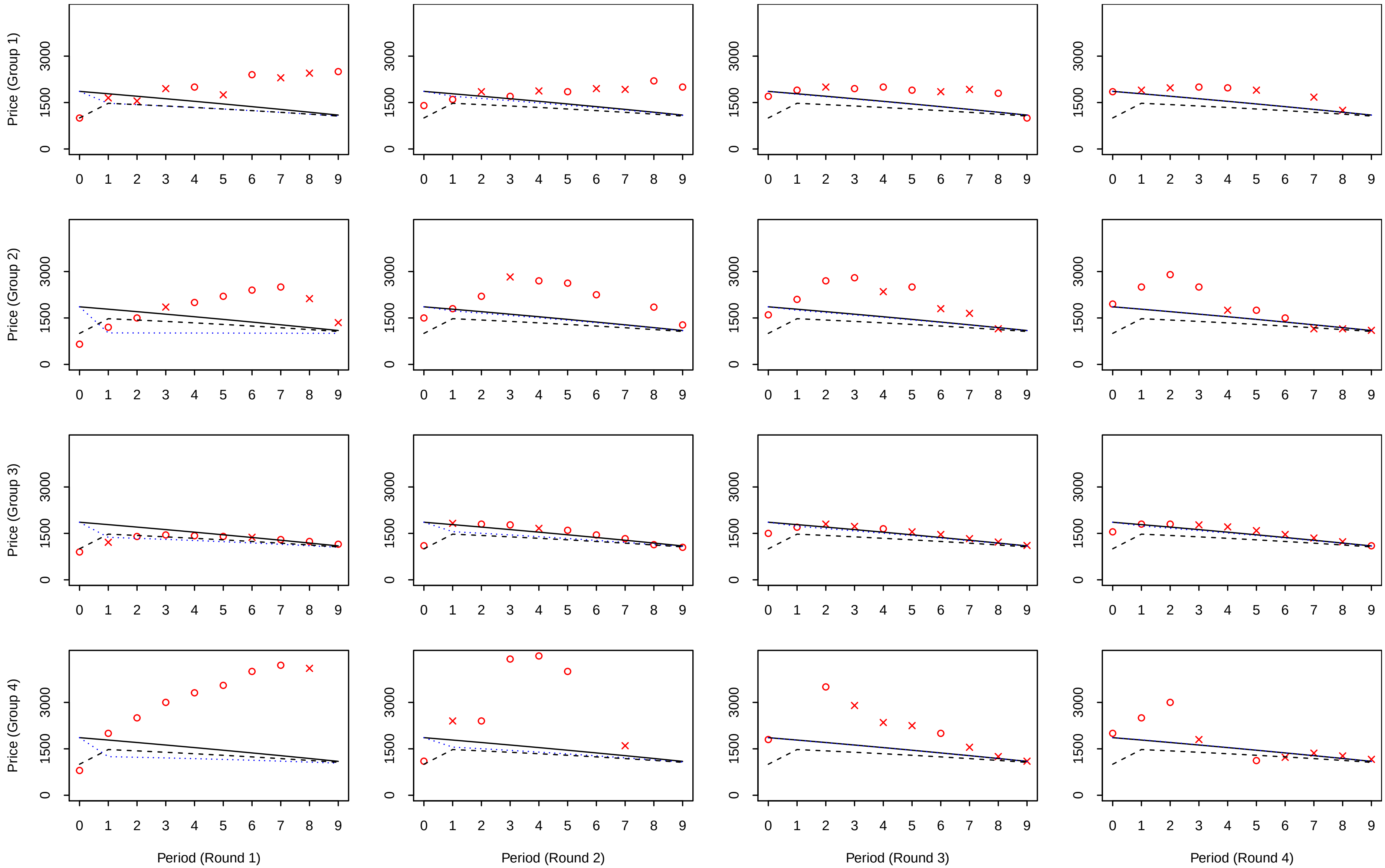

Figure 1: Bond Market Prices in all Periods and Rounds, Groups 1 to 4, Treatment *REG*

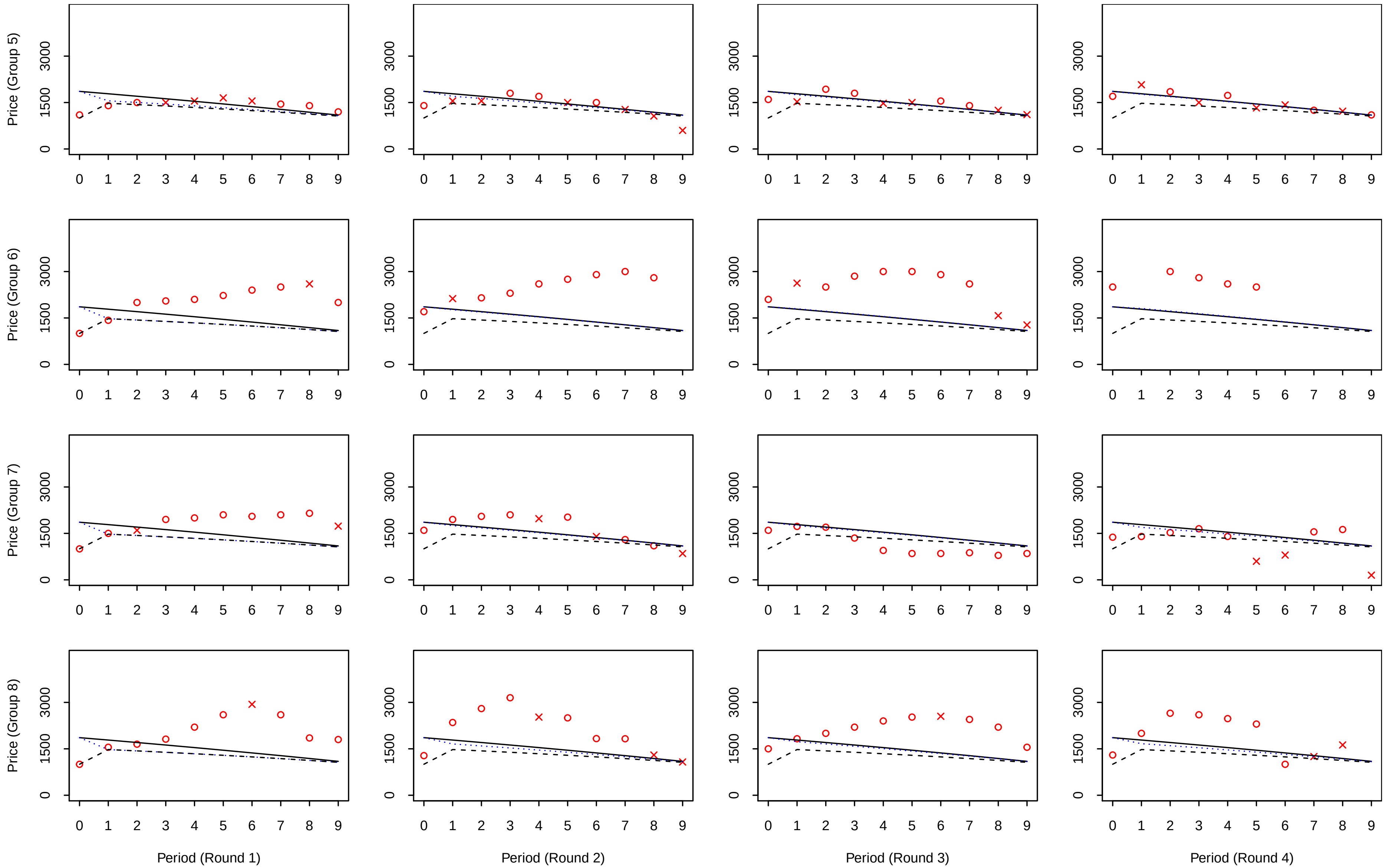

Figure 2: Bond Market Prices in all Periods and Rounds, Groups 5 to 8, Treatment *REG*

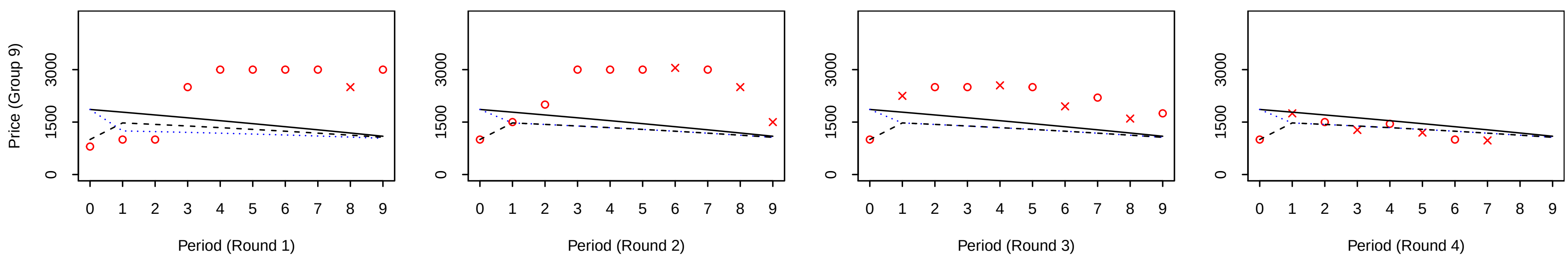

Figure 3: Bond Market Prices in all Periods and Rounds, Group 9, Treatment *REG*

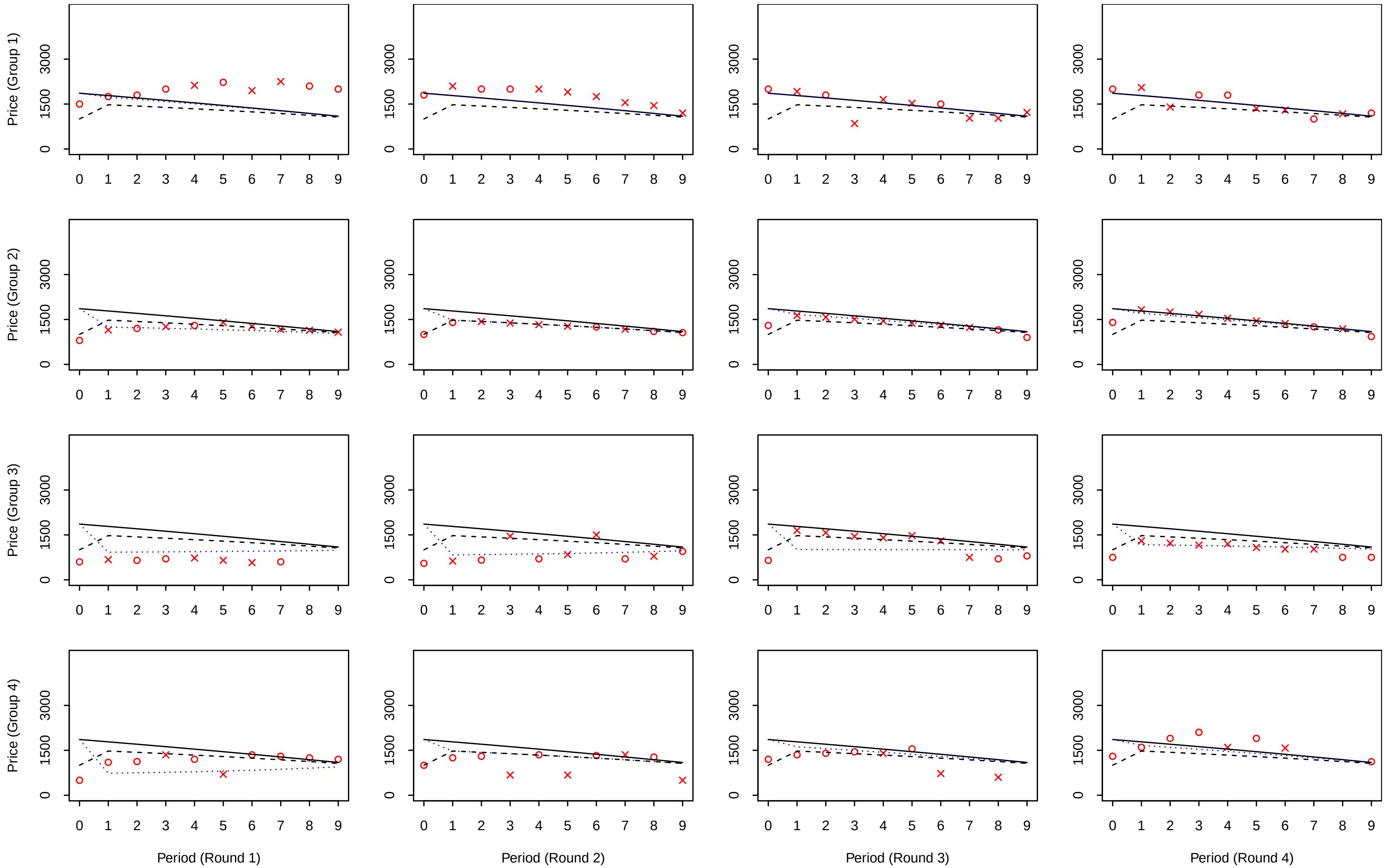

Figure 4: Bond Market Prices in all Periods and Rounds, Groups 1 to 4, Treatment *FREE*

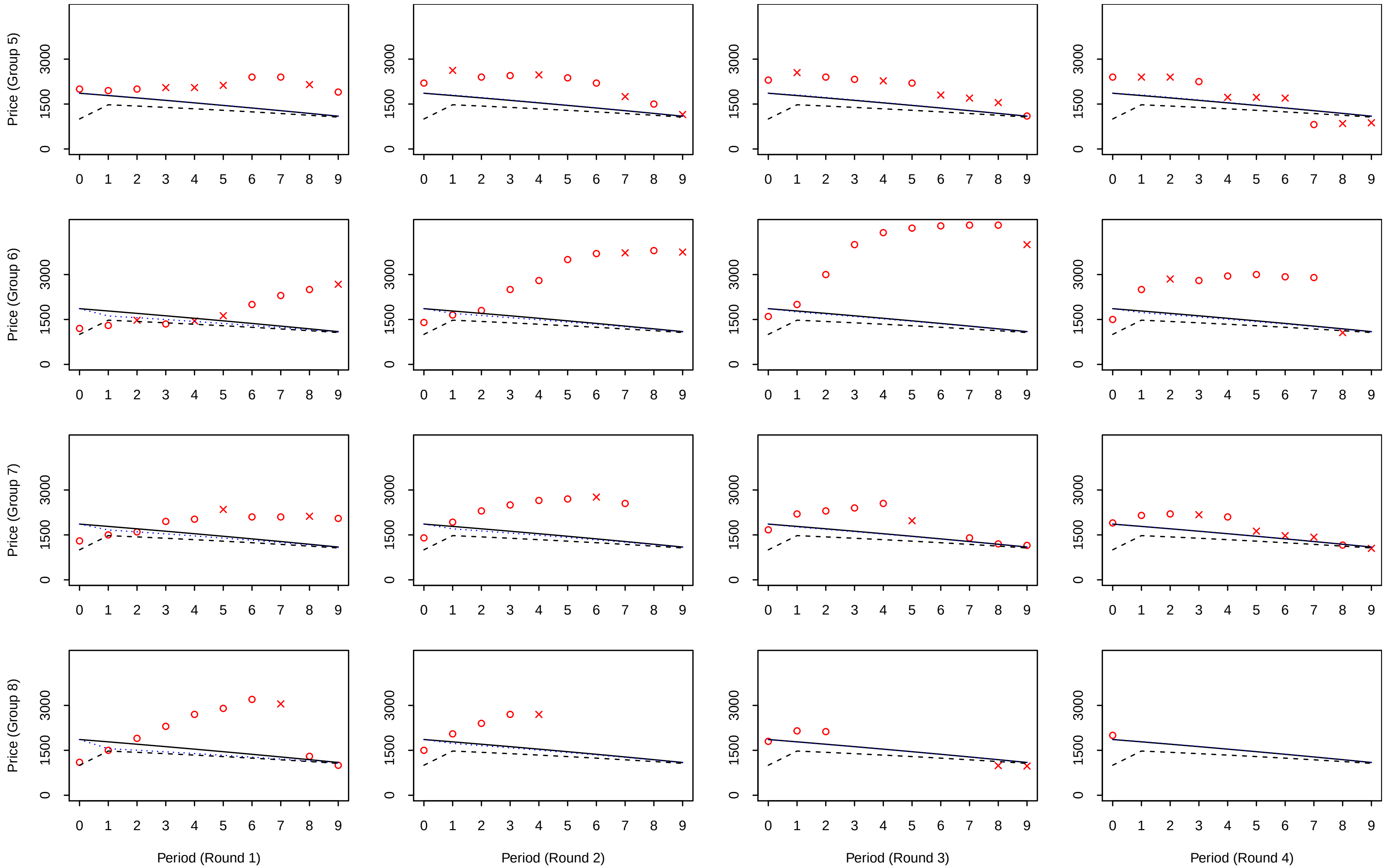

Figure 5: Bond Market Prices in all Periods and Rounds, Groups 5 to 8, Treatment *FREE*

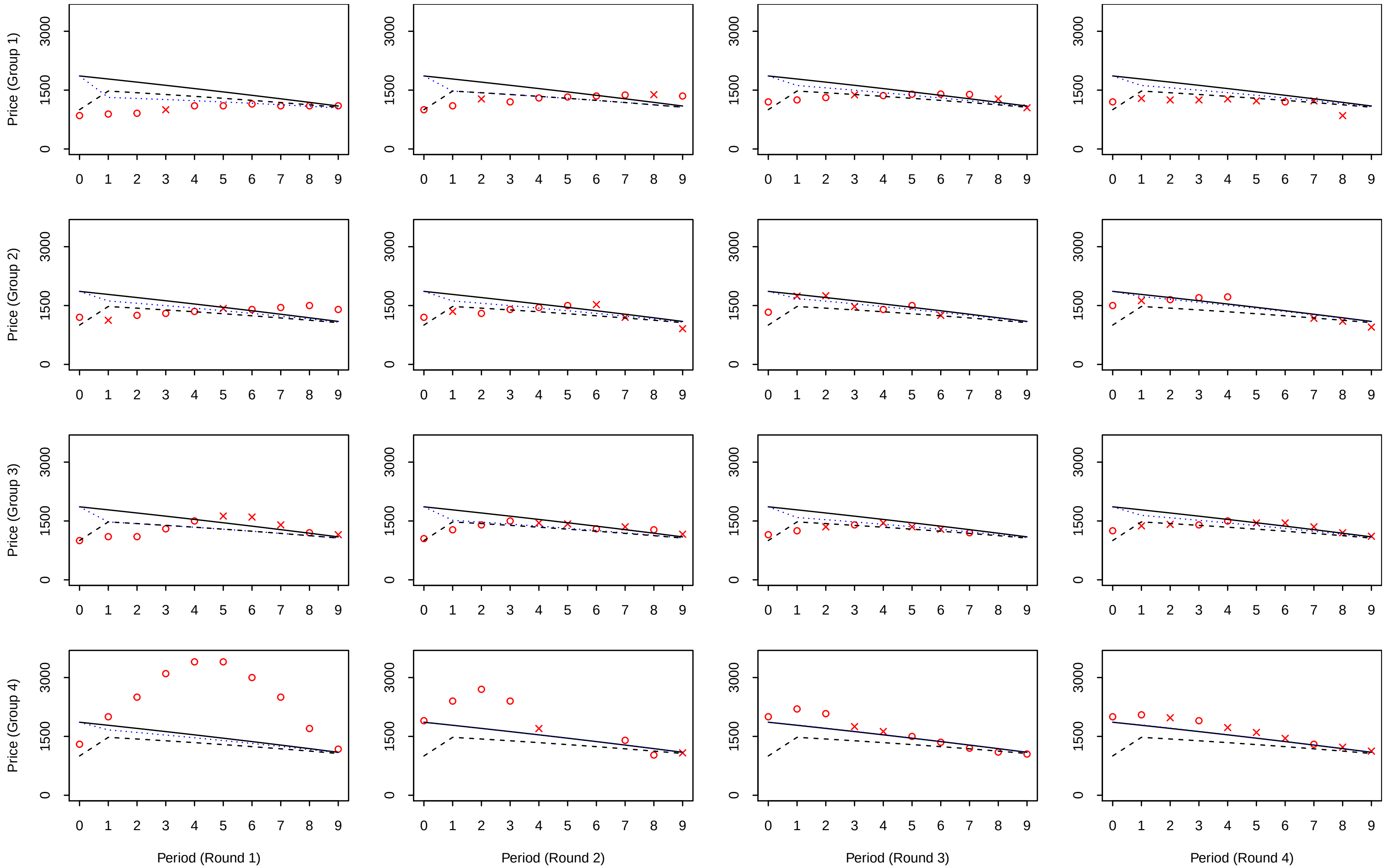

Figure 6: Bond Market Prices in all Periods and Rounds, Groups 1 to 4, Treatment *Control* (Weber et al., 2018)

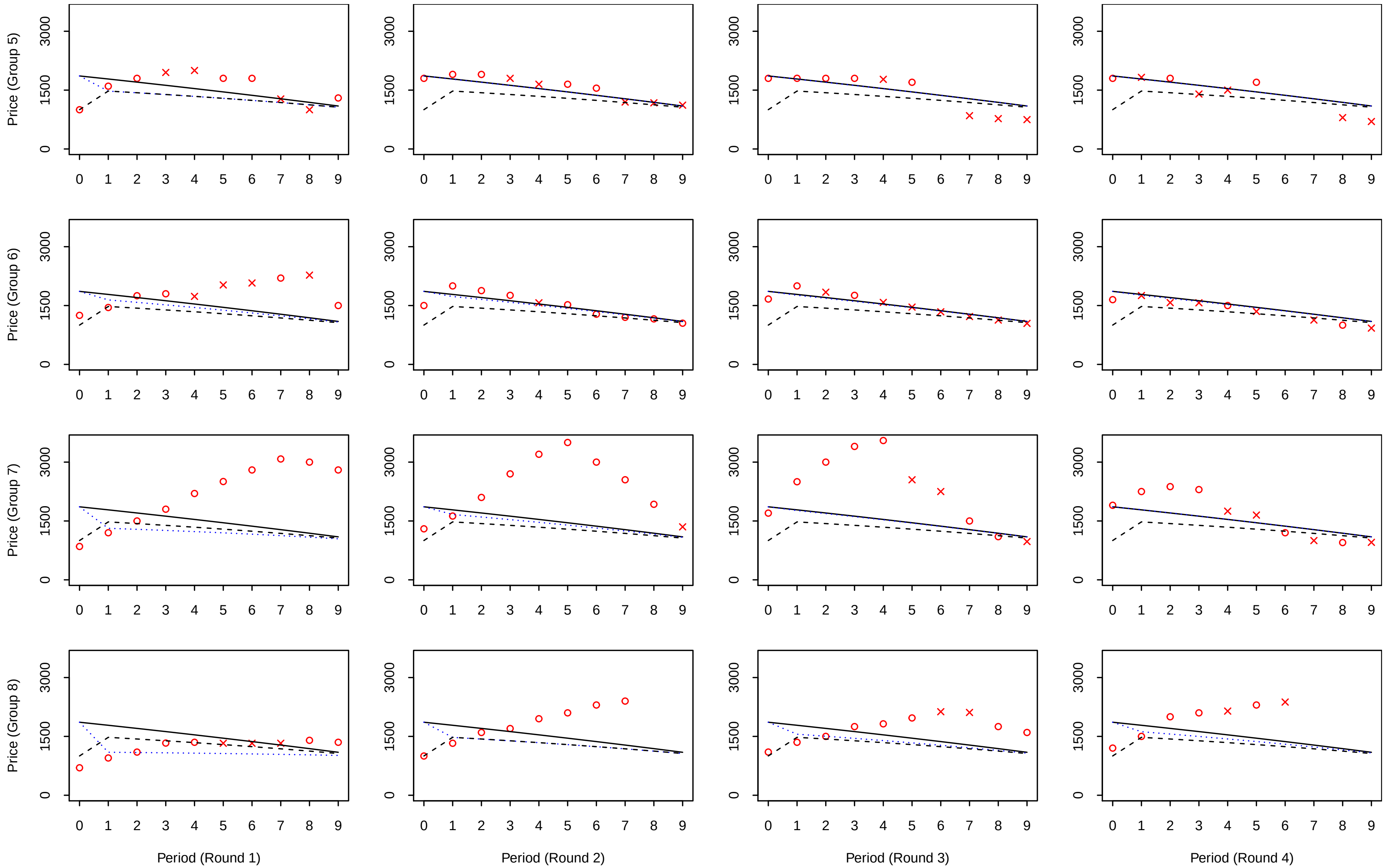

Figure 7: Bond Market Prices in all Periods and Rounds, Groups 5 to 8, Treatment *Control* (Weber et al., 2018)

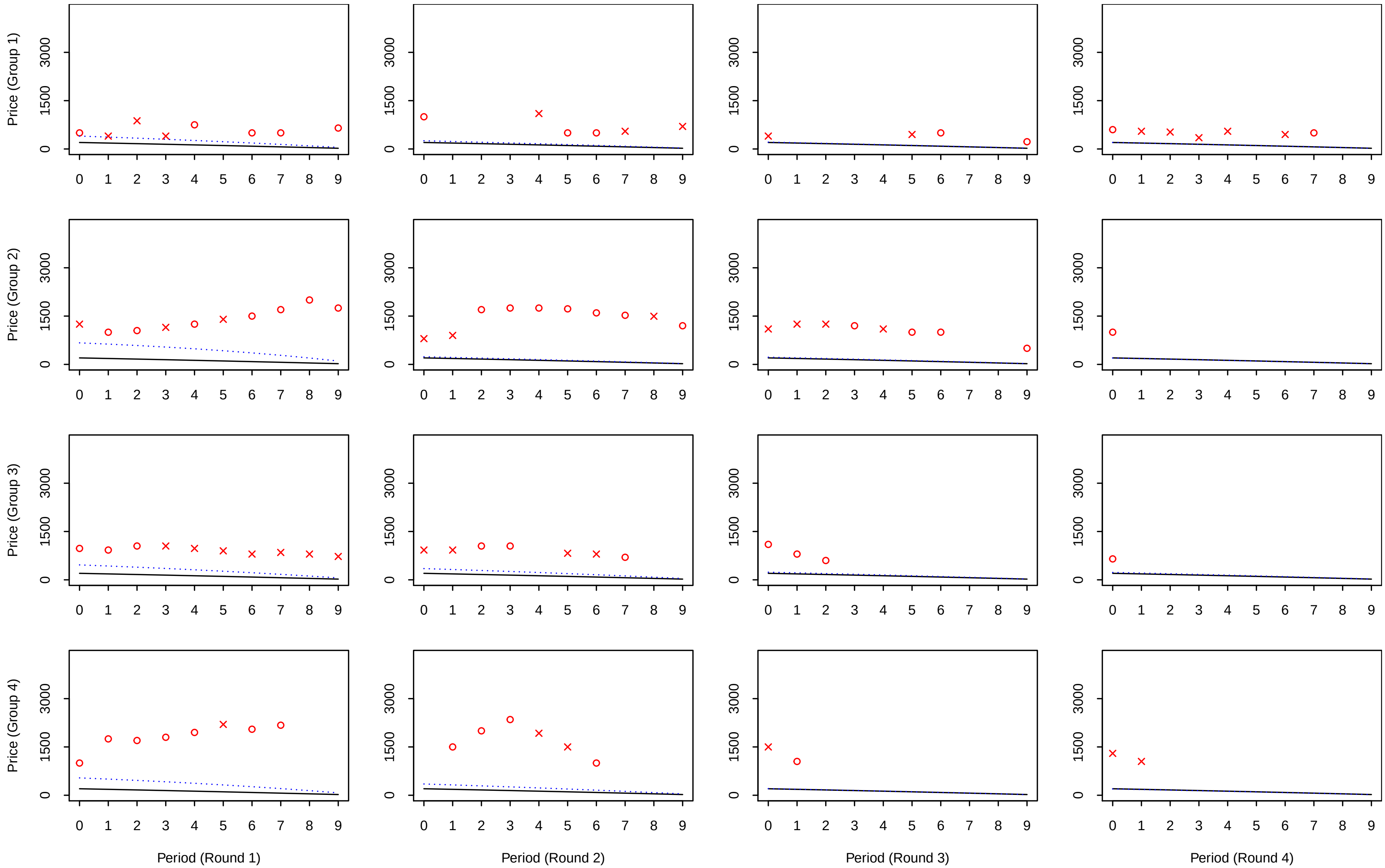

Figure 8: CDS Market Prices in all Periods and Rounds, Groups 1 to 4, Treatment *REG*

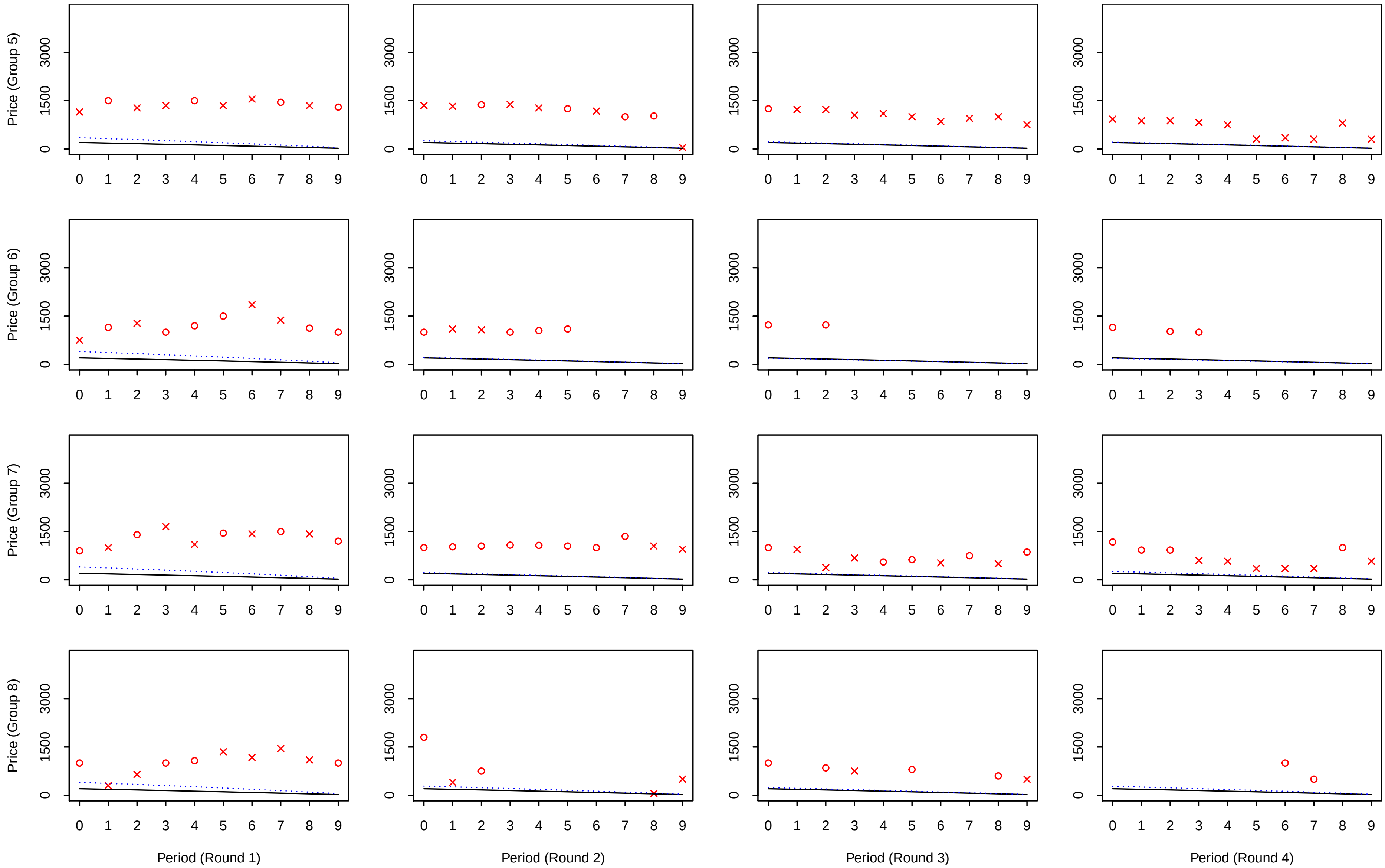

Figure 9: CDS Market Prices in all Periods and Rounds, Groups 5 to 8, Treatment *REG*

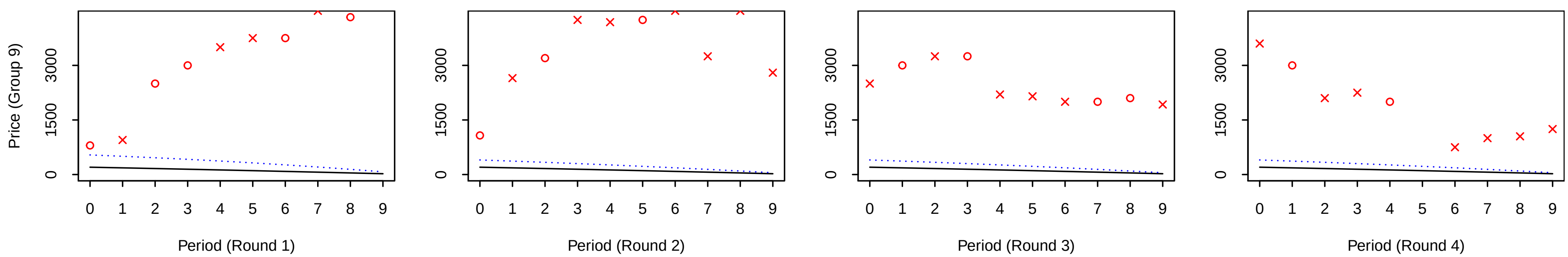

Figure 10: CDS Market Prices in all Periods and Rounds, Group 9, Treatment *REG*

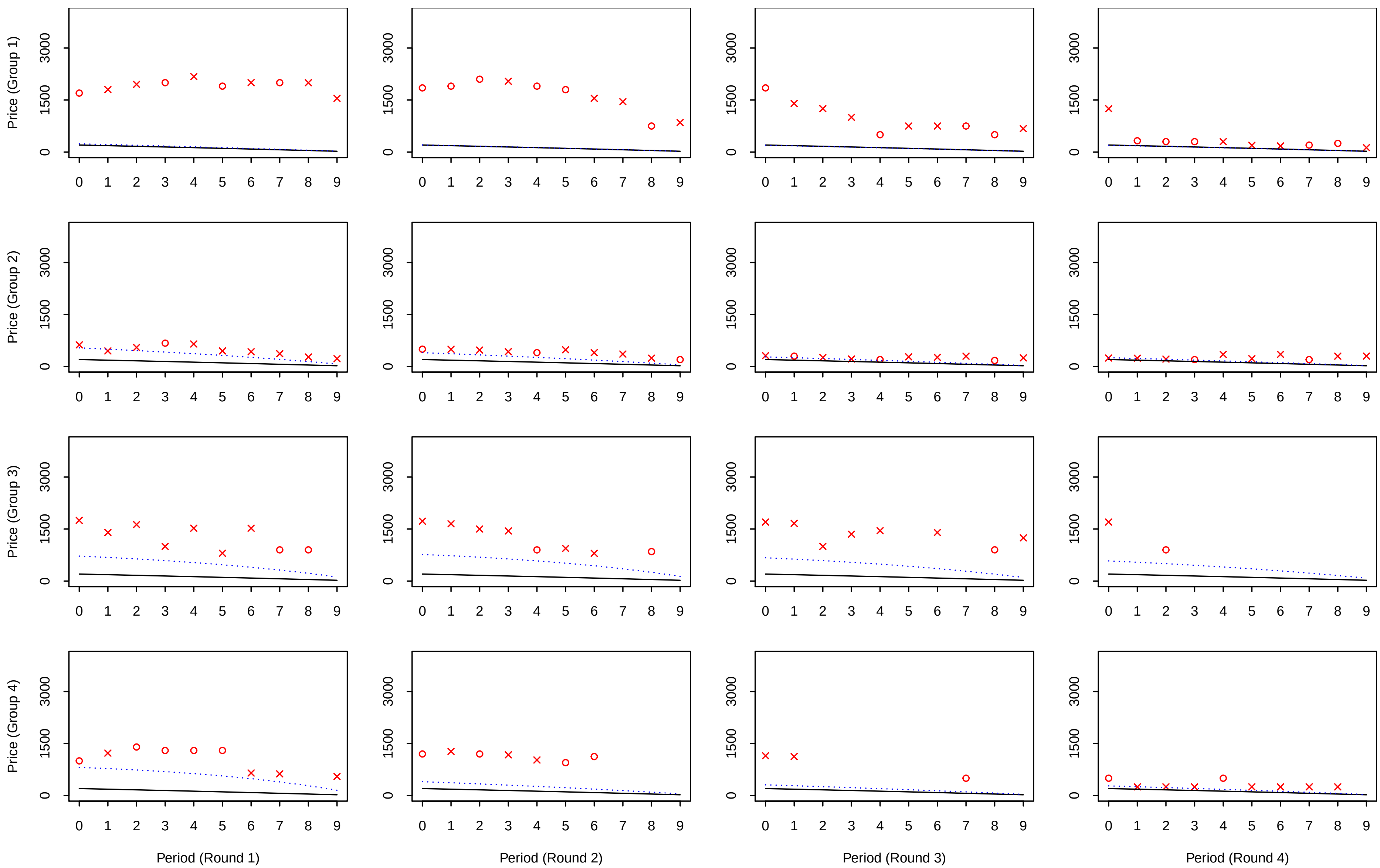

Figure 11: CDS Market Prices in all Periods and Rounds, Groups 1 to 4, Treatment *FREE*

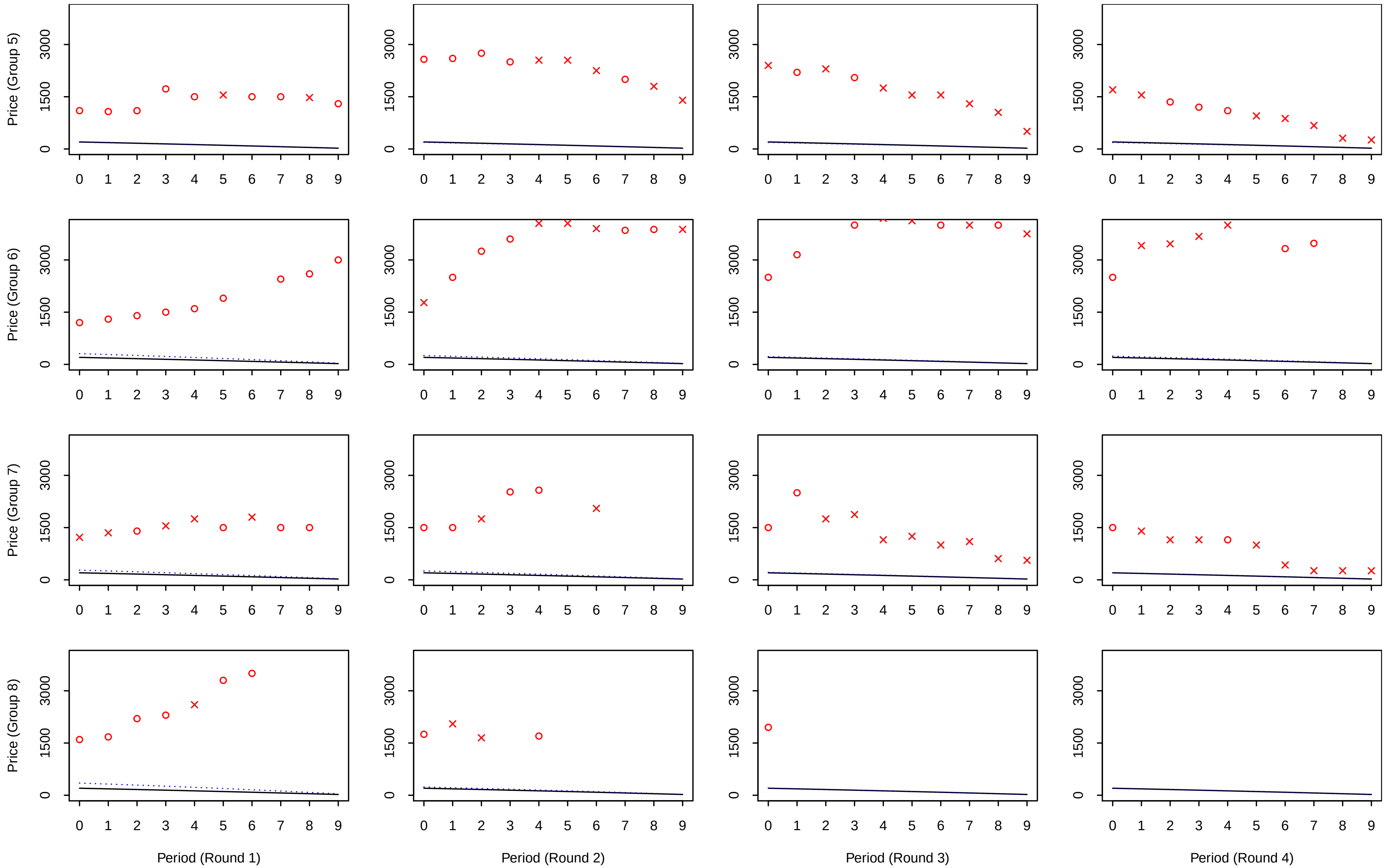

Figure 12: CDS Market Prices in all Periods and Rounds, Groups 5 to 8, Treatment *FREE*