Differentiated Assets: An Experimental Study on Bubbles[†]

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Abstract

In this paper, we study if and how having two differentiated assets affects bubble formation. We consider differences in assets' intrinsic characteristics as well as trading regulations that help differentiate two otherwise identical assets. We find that, compared to trading regulations, differences in assets' intrinsic characteristics encourage more arbitrage across assets and thus help reduce mispricing significantly. We also find that short-term speculation does not depend on how assets or markets are being differentiated. As a result, short-term speculation cannot be used to explain why bubbles are smaller when two assets are intrinsically different than when they are not.

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1. Introduction

The bubble-and-crash phenomenon in experimental asset markets, first reported in Smith, Suchanek, and Williams (1988), has been shown to be rather robust to various manipulations in the experimental design (see, for example, King et al. (1993), Van Boening et al. (1993), Porter and Smith (1995)).[1] In all these markets, an asset with a life of 15 or 30 periods is traded. The asset pays a common dividend to all holders at the end of each trading period; and the dividend structure is common knowledge to all traders. Rather than tracking the fundamental value, which is derived from the expected dividend for the number of periods remaining, prices tend to exhibit a prolonged boom and crash pattern in a vast majority of the markets studied in the literature.

Note that the bubble-and-crash phenomenon has also been observed in a setting where two assets are traded in two separate double-auction markets simultaneously. Fisher and Kelly (2000) study rate-of-return parity in such an environment. The main treatment variable that they consider is the expected dividends of the assets. In some treatments the two assets pay exactly the same expected dividend, whereas in some others one asset pays twice as much. They find that bubbles not only exist in both markets, but that they are positively correlated with each other. Childs and Mestelman (2006) manipulate the expected dividend as well as the variance of the dividends. Their findings are consistent with Fisher and Kelly's in that bubbles occur in both

[1] In addition to trading experience that has been shown to be able to consistently eliminate bubbles (see Smith et al., 1988; Van Boening et al., 1993; Dufwenberg et al., 2005; Haruvy et al. 2007), Noussair and Tucker (2006) find that the presence of a complete set of futures markets is able to facilitate backward induction and thus help eliminate bubbles in the spot market. Lei and Vesely (2009) find that a pre-market phase in which subjects passively experience the realization of a dividend stream can prevent bubbles from occurring. Lugovskyy et al. (2010) study a tâtonnement trading institution that is used to address the lack of common knowledge of rationality as well as the lack of rationality itself. They find that bubbles are significantly attenuated with the tâtonnement trading institution.

markets and that rate-of-return parity receives less support as the assets become more differentiated.

In this paper, we focus on bubble formation in a setting where two assets are traded simultaneously. Specifically, we ask if and how the existence of two differentiated assets helps alleviate bubbles. Empirical evidence from the naturally occurring world certainly suggests that some markets (e.g., bond markets) are less susceptible than others to the dramatic boom-and crash price pattern.[2] Is it because those markets consist of securities that have characteristics that would encourage investors to exercise more arbitrage and less speculation? The goal of this paper is thus to explore different aspects of differentiation between two assets and see if and how they help reduce mispricing in the market.

We first consider the situation where two assets differ in terms of their intrinsic characteristics. We construct markets in which subjects are free to buy and/or sell assets called X and Y. Trading is organized in a side-by-side fashion. To see if and how the existence of two intrinsically differentiated assets affects the formation of bubbles, we adopt a 2×2 design in which the two treatment variables are asset Y's life duration and expected per period dividend. Asset X's characteristics, including a life of 30 periods and an expected dividend of 7 francs per period, are fixed across all four treatments (SdurSdiv, SdurDdiv, DdurSdiv, and DdurDdiv). Asset Y' characteristics, on the other hand, vary across treatments. It pays either the same expected dividend as X or twice as much. In terms its life duration, it lasts either 30 or 15 periods.

We then investigate if and how trading regulations that help differentiate two otherwise identical assets affect the intensity of bubbles. The two trading regulations that we consider include a securities transaction tax and a minimum holding period requirement. In a treatment

[2] See, for example, Johnson and Young (2002), Young and Johnson (2004), and Jones and Wilson (2004) for bond market volatility vs. stock market volatility.

called Taxy, a fixed transaction tax that is about 0.5% of the initial fundamental value is imposed on asset Y. The intrinsic characteristics of X and Y are exactly the same as in the baseline SdurSdiv treatment. Note that a securities transaction tax (STT) or a Tobin tax has long been considered by some as a policy tool that would help curb short-term speculation, reduce volatility, and improve market efficiency in stock or foreign exchange markets (see, for example, Tobin, 1984; Stiglitz, 1989; Summers and Summers, 1989; Palley, 1999). Nevertheless, skeptics argue that the adverse effects of a STT on market liquidity may well destabilize the market rather than stabilize it. For instance, Kupiec (1995) argues that a STT that reduces a taxed asset's liquidity may increase investors' required rate of return and thus make it difficult to mitigate the degree of mispricing. Schwert and Sequin (1993) note that, since a STT affects noise and fundamental traders indiscriminately, it is not clear if the tax would have a greater impact on noise traders. There are also concerns over the coverage or the enforcement of a STT. Campbell and Froot (1994) argue that a STT would encourage traders to shift trading from the taxed asset to its untaxed close substitutes or from the domestic market to offshore ones. The migration from one market to another, according to Westerhoff and Dieci (2006), generates an ambiguous impact on the markets as a whole.

Given these conflicting ideas, one might imagine that the debate would be settled with empirical evidence. Unfortunately, empirical studies undertaken so far have yet been able to produce much convincing evidence to suggest that STTs can help reduce market volatility in either stock or foreign exchange markets (see, for example, Roll, 1989; Umlauf, 1993; Dooley, 1996; Hu, 1998; Aliber et al., 2003). In the experimental literature, there have been only a few studies that investigate the effects of transaction fees or STTs on bubble magnitude or market volatility. King et al. (1993) find that a fixed transaction fee has mixed effects on the intensity of bubbles. Bloomfield et al. (2009) find that a STT discourages informed traders' activity as much as it does to the uninformed. As a result, the tax has no significant impact on pricing errors or market efficiency. Both King et al. and Bloomfield et al. investigate the effects of STTs in a single-market environment and thus cannot address issues concerning trading migration from a taxed asset to its untaxed substitutes. Hanke et al. (2010) is the only study that introduces a STT in a two-market setting. In a treatment where only one asset is subject to the transaction tax, Hanke et al. observe that a significant amount of trading shifts to the untaxed market and that market efficiency decreases dramatically in the taxed one. Our Taxy treatment differs from Hanke et al. in the following ways. First, assets' fundamental values in Hanke et al. follow a random walk without drift, implying that, in any given period, future fundamental values are not known to subjects. In our study, fundamental values follow a downward trend that is constructed in the same way as in Smith et al. (1988). Also as in Smith et al., both current and future fundamental values are common knowledge to all traders. Therefore, we believe that our study is much simpler and more comparable to the literature pioneered by Smith et al.. Second, while Hanke et al. use a tax rate of 0.5%, we choose a fixed transaction fee in order to further simplify our environment.

Contrary to a more indirect, market-based transaction tax, direct restrictions on capital mobility have been adopted in various forms by numerous countries to fight asset bubbles and currency appreciation.[3] To deal with surges in capital inflows, Indonesia is one of the most recent examples to implement control measures including a one-month minimum holding period on certain securities. In a treatment called Holdy, we consider a policy tool similar to this rather straightforward intervention to differentiate assets X and Y. Specifically, we introduce a

[3] See Ariyoshi et al. (2000) and Ostry et al. (2010) for summaries of capital controls that have been adopted since 1990s.

minimum holding period of 5 that is imposed only on asset Y. To our knowledge, the only experimental study that has investigated the impact of a similar trading restriction, though for a completely different purpose, is Lei et al. (2001). To investigate if speculation is necessary to create bubbles, Lei et al. remove subjects' ability to speculate by imposing a ban on reselling any shares acquired earlier in the experiment. They find that the ban on the reselling is not able to moderate the magnitude of bubbles unless a commodity market is also operated alongside. Note that the purpose of introducing a commodity market in Lei et al. is to simply divert excess trade that is thought to be related to decision errors in the asset market. As such, the commodity market is operated with a simple one-period supply and demand structure repeated under stationary conditions. Their laboratory environment is thus dramatically different from ours in that we have two markets operated simultaneously for trading assets that are perfect substitutes in terms of their fundamental values.

As reported in detail in Section 3, the price patterns of both assets in the baseline treatment (SdurSdiv) exhibit the same bubble-and-crash phenomenon as observed in the literature. The two bubbles coincide with one another in most of the SdurSdiv sessions, which is consistent with the results reported by Fisher and Kelly (2000) and Childs and Mestelman (2006). In the other three treatments where X and Y have different intrinsic characteristics, deviations from fundamental values are significantly smaller than in the baseline treatment. In some of the sessions especially those in DdurSdiv, prices tend to track the fundamental rather well. The observation that bubbles are dramatically attenuated is, however, not accompanied by significantly smaller turnovers.

The data from the treatments of Taxy and Holdy, reported in Section 4, suggest that neither trading regulation has a significant impact on reducing the size of bubbles. The observation that the two bubbles are almost identical in the baseline treatment continues to hold true here.

To explain why bubbles are significantly smaller in the treatments of SdurDdiv, DdurSdiv, and DdurDdiv, we decompose traders' trading activities within a given period into various categories through which the frequencies of arbitrage and short-term speculation can be constructed. We find that having two intrinsically differentiated assets tend to generate more arbitrage across assets and, as a result, reduce the magnitude of bubbles. The frequency of short-term speculation, on the other hand, does not depend on if and how assets or markets are being differentiated. Its correlation with the bubble amplitude is positive yet insignificant. Overall, our results highlight the importance of promoting a more diversified market environment as a policy tool to improve efficiency.

The rest of our paper is organized as follows. Section 2 describes the experimental design and procedures. Sections 3, 4 and 5 report the results. Section 6 concludes the paper.

2. The Experiment

The experiment consisted of twenty-two sessions conducted at a large state university between May 2007 and June 2009. A total of 215 subjects were recruited from City University of Hong Kong via email. Some of the subjects may have participated in economics experiments before, but none had any experience in experiments similar to ours. No subject participated in more than one session of this study. On average, sessions lasted three hours including software training, initial instruction period and payment of subjects. The experiment was programmed using the Ztree software package (Fischbacher, 2007). Trade was denominated in an experimental currency, called "francs", which was converted to Hong Kong dollars at a predetermined and publicly known conversion rate. Including a participation fee of HK$20, subjects earned an average of HK$186 (roughly US$24).[4]

There were 30 trading periods in each of the twenty-two sessions, and each period lasted 3 minutes. At the beginning of period 1, subjects were endowed with 5 units of an asset called X, 5 units of another asset called Y, and 10,000 francs of working capital. In each period, there were two markets open side-by-side for trading X and Y. Subjects were free to buy and/or sell in either or both markets using continuous double auction rules. Inventories of X and Y were carried over from one period to the next until the end of their lives. The cash balance, on the other hand, was carried over from period to period all the way to period 30.

To study the impact of differences in assets' intrinsic characteristics on bubbles and crashes, we adopted a 2×2 design in which the two treatment variables were asset Y's maturity and expected dividend per period. More specifically, there were four treatments depending on whether or not assets X and Y had the same life duration and/or expected dividend per period. The characteristics of asset X described in the following were fixed across all four treatments. First, it had a life of 30 periods. Second, it paid a dividend that was drawn from a distribution of (2, 4, 6, 8, 10, 12), each with equal probability, at the end of each trading period. In other words, X's expected dividend was fixed at 7 francs per period. Asset Y, on the other hand, had a life of either 15 or 30 periods. In those treatments where Y's life ended at the end of period 15, subjects were given another 5 units of Y so that the total stock of units remained constant in all periods.[5] Depending on the treatment, asset's Y's dividend payment was drawn either from (2, 4, 6, 8, 10, 12) or from (4, 8, 12, 16, 20, 24). As a result, in two of the four treatments, asset Y's expected

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[4] Back in 2007, workers at fast food chains in Hong Kong earned an average hourly rate that was less than US$3.00.
[5] In the instructions, we called the units of Y whose lives started from period 1 and ended at the end of period 15 asset Y1, and those units whose lives started from period 16 and ended at the end of period 30 asset Y16. Subjects were reminded that there was no difference between Y1 and Y16 except that Y1's life started from period 1 and Y16's life started from period 16.

dividend per period was the same as asset X's; whereas in two others, it was twice as much. The random draw for asset Y at the end of each period was independent from that for asset X. Asset X's and Y's dividend distribution and expected dividend per period were public information among traders. Tables that described X's and Y's expected dividend streams and thus their fundamental values in any given period were also provided to subjects. The expected dividend stream of asset X at the beginning of period t equaled $7*(31-t)$, where $(31-t)$ was the number of periods remaining before X expired. The expected dividend stream of asset Y was calculated in a similar fashion. Summary information for each of the four treatments—SdurSdiv, SdurDdiv, DdurSdiv, and DdurDdiv—is given in Table 1.

[Table 1: About Here]

Of the four treatments described above, we considered the one in which X and Y were identical (SdurSdiv) as our benchmark. With this benchmark treatment, we conducted two follow-up treatments in which differences between X and Y came from institutional regulations. In the treatment called Taxy, we introduced a securities transaction tax of 2 francs, equivalent to 29% of the expected per period dividend, on asset Y (1 franc each on the buyer and seller in every trade). In the treatment called Holdy, we imposed a minimum holding period on asset Y. More specifically, traders were required to hold asset Y for at least 5 consecutive periods from the time they acquired it on the market. Summary information regarding these two treatments is also provided in Table 1.

3. Results for Differences in Assets' Intrinsic Characteristics

The left-hand panels of Figure 1 provide the time series of median transaction prices in all four sessions of the benchmark SdurSdiv treatment. In each of these panels, the closed squares/triangles connected with a black/gray solid line represent the median transaction prices of X/Y; whereas the line without any symbols represents the time series of the fundamental values.[6] It is clear that asset X's and asset Y's prices are highly correlated and, more importantly, they both follow the robust bubble-and-crash pattern. For instance, in session SdurSdiv1, both assets' prices start a bit higher than the fundamental value and stay high until they finally collapse in period 17. In session SdurSdiv2, X's median period price gradually escalates until period 27 when a sudden crash finally occurs. A similar pattern is also observed for asset Y. These observations are consistent with the results reported by Fisher and Kelly (2000) and Childs and Mestelman (2006) in that rate-of-return parity is supported between two identical dividend-paying assets, but not between the assets and currency.

[Figure 1: About Here]

The time series of median transaction prices in the SdurDdiv sessions are shown in Figure 2. Bubbles occur in sessions SdurDdiv1 and 2. Price deviations of asset Y appear to be much larger than those of asset X in SdurDdiv1. As a consequence, the relative price ratio between X and Y in this treatment does not conform to rate-of-return parity as closely as that in the SdurSdiv treatment.

[Figure 2: About Here]

The left-hand panels of Figure 3 provide the time series of median transaction prices in treatment DdurSdiv. Note that, since asset X pays the same expected per-period dividend but lasts twice as long as asset Y, rate-of-return parity predicts that the price ratio between X and Y will be $(31-t)/(16-t)$ between periods 1 and 15 but 1 between periods 16 and 30. This prediction appears to be supported in sessions DdurSdiv1, 3, and 4, mainly because the robust bubble-and-

[6] In Figure 1 and all subsequent figures in the paper, an open square or triangle indicates that no transaction took place during that period, and the value indicated as the median price is the midpoint between the final bid-offer spread.

crash phenomenon, surprisingly, does not manage to emerge in these three sessions. Price deviations from the fundamental, on the other hand, exist for both assets in the first half of session DdurSdiv2. Nevertheless, they tend to be much smaller in size compared to those in the benchmark treatment.

[Figure 3: About Here]

The time series of median transaction prices in the three DdurDdiv sessions are given in Figure 4. Although bubbles are observed in all three sessions, their magnitudes are considerably smaller than those in the benchmark SdurSdiv. On the other hand, compared to the benchmark treatment, price patterns shown in Figure 4, especially in sessions DdurDdiv1 and 2, provide weaker support for rate-of-return parity which predicts that the price ratio between X and Y will be $(31-t)/2(16-t)$ and 0.5 in the first and second halves of the experiment, respectively.

[Figure 4: About Here]

Finally, we provide trading volumes in the right-hand panels of Figures 1-4. More asset X than asset Y was traded in the benchmark SdurSdiv treatment.[7] This trading pattern, however, disappeared in the rest of the three treatments.

3.1 Treatment Effects on Price Deviation and Turnover

Table 2 provides the statistical summary of bubble measures that are the same as or similar to those used in previous studies.[8] The *Price Amplitude* of a bubble, first reported by King et al. (1993), is defined as the difference between the peak and the trough of average price

[7] Since asset X was displayed on the left side of the screen in our experiment, this result is consistent with the observation in Hanke et al. (2010) in that most trading took place in the Left market than in the Right market even though both assets were exactly identical.

[8] See, for example, King et al. (1993), Van Boening et al. (1993), Porter and Smith (1995), Noussair et al. (2001), and Haruvy and Noussair (2006).

deviations over the life of the asset: $\max_t\{(P_t - f_t)/f_1\} - \min_t\{(P_t - f_t)/f_1\}$, where P_t and f_t are the median transaction price and the fundamental value in period *t*, respectively. We also report the *Normalized Average Bias* modified from the average bias reported by Haruvy and Noussair (2006). Specifically, to take into account of various fundamental patterns that are resulted from different maturity and/or different dividend payments, we define the *Normalized Average Bias* as the average deviation of period median price from the period fundamental over the asset's life duration *T*, normalized by the initial fundamental value. That is, *Normalized Average Bias* = $\frac{\sum_t (P_t - f_t)}{f_1} \Big/ T$.[9] For the same reason, the *Normalized Average Deviation* in our paper is defined as the sum of all absolute price deviations that is adjusted with the asset's total stock of units, life duration, and the initial fundamental value. That is, *Normalized Average Deviation* = $\frac{\sum_t \sum_i |p_{it} - f_t|}{f_1} \Big/ (T \times TSU)$, where p_{it} denotes each transaction price *i* in period *t* and *TSU* is the total stock of units.[10] Finally, we average the turnover over the entire course of the asset's lifetime: *Average Turnover* = $\sum_t q_t / (T \times TSU)$.

[Table 2: About Here]

The results reported in Table 2 roughly confirm the discussion described above. The price amplitude, normalized average bias, and normalized average deviation of both asset X and asset Y1 (asset Y whose life started from period 1) are, generally speaking, the largest in SdurSdiv and the smallest in treatment DdurSdiv. In those sessions where asset Y had a life of only 15 periods, the sizes of the bubbles in market Y16 are smaller than those in market Y1. The result that bubble measures decline with experience is consistent with the results reported in

[9] In Haruvy and Noussair (2006), the average bias is defined as $\sum_t (P_t - f_t)/T$, where *T* denotes asset's life duration.

[10] The normalized deviation reported in previous studies is defined as $\sum_t \sum_i |p_{it} - f_t| / TSU$.

Smith et al. (1988) and King et al. (1993). In terms of quantities traded, SdurSdiv and SdurDdiv have the highest and lowest average turnover, respectively, among the four treatments.

Given that cross-sectional and time-series variation in the data is not controlled for, it is perhaps premature to assign much significance to the results reported in Table 2. Therefore in the following analysis, we adopt a generalized least squares (GLS) random-effects model to investigate the treatment effects on price deviations $\left|P_t^i - f_t^i\right| / f_1^i$ and turnover q_t^i / TSU^i, where i = X and Y. Note that, since asset Y had a shorter maturity in DdurSdiv and DdurDdiv than in SdurSdiv and SdurDdiv, we employ data only from periods 1 to 15 whenever asset Y is involved in the regression. Results given in Table 3 include time period t and dummy variables Ddiv and Ddur that equal 1 if assets differ in their dividend structure and maturity, respectively. An interaction term between Ddiv and Ddur is also included.

[Table 3: About Here]

RESULT 1: *Price deviations are the largest when both assets share exactly the same intrinsic characteristics (baseline SDurSdiv). Introducing differences in assets' maturity period, dividend structure or both (treatments SdurDdiv, DdurSdiv, and DdurDdiv) significantly reduces price deviations for both assets. Overall, price deviations for the market as a whole are significantly smaller in these three treatments.*

SUPPORT FOR RESULT 1: The estimates shown in column (1) of Table 3 imply that, compared to the baseline treatment (SdurSdiv), having an alternative asset that has the same maturity but pays a double expected dividend (SdurDdiv) reduces X's price deviations by an average of 43.49% per period. Asset X's price deviations are on average 46.29% lower than in the baseline treatment when Y pays the same expected dividend but has a life duration that is only half of asset X's (DdurSdiv). The treatment effect of having an alternative asset Y that differs not only in its maturity but also in its expected dividend payment (DdurDdiv) is –43.49 – 46.29 + 49.74 = –40.04%, which is significantly different from zero (χ^2 = 11.01, *p*-value = 0.0009). The estimates reported in column (3) suggest that, compared to the baseline treatment, asset Y's price deviations between periods 1 and 15 are on average 23.50%, 28.56%, and 25.04% (χ^2 = 10.82, *p*-value = 0.0010) lower in the SdurDdiv, DdurSdiv, and DdurDdiv treatments, respectively. And for the market as a whole, we look at the average deviation of the two assets and report the regression result in column (5). Overall, the average price deviations in the market in the first fifteen periods are significantly lower if the two assets differ in at least one of the two aspects, indicating that the existence of differentiated assets helps stabilize the market. Finally, we test if the hypothesis that SdurDdiv, DdurSdiv, and DdurDdiv generate the same treatment effects and yield *p*-values of 0.8743, 0.7856, and 0.7985 for asset X, asset Y, and the overall market. ■

RESULT 2: *Assets' turnovers are mostly unaffected by the differences between the two assets.*

SUPPORT FOR RESULT 2: The estimates shown in columns (2) and (6) of Table 3 indicate that, after cross-sectional and time-series variation in the data is controlled for, asset X's and thus the overall market's turnovers are marginally lower in SdurDdiv than in the baseline SDurSdiv. Neither of the two other treatments has any significant impact on the turnovers. Having said that, the hypothesis that SdurDdiv, DdurSdiv, and DdurDdiv have the same treatment effects cannot be rejected by our data (*p*-value = 0.8285 and 0.8532 for asset X and the overall market, respectively). ■

3.2 Treatment Effects on the Deviation from Rate-of-Return Parity

In this section, we investigate the treatment effects on the deviation of P_t^X / P_t^Y from the prediction of rate-of-return parity. Again, to avoid the possibility that the treatment effects are confounded by different experience levels in trading asset Y during the second half of the experiment, only the first 15 periods' data are used here. Column (1) of Table 4 reports the mean deviation averaged over periods 1 to 15 in each of the four treatments.

[Table 4: About Here]

P_t^X / P_t^Y deviates from the prediction by an average of 5.82% per period in SdurSdiv. In contrast, the average deviations in the other three treatments are generously negative. The mean deviations are −4.28%, −3.38%, and −7.63% per period in SdurDdiv, DdurSdiv, and DdurDdiv, respectively. In the following, we turn to the same random-effects model as described above for the treatment effects that take the cross-sectional and time-series variation in the data into consideration.

RESULT 3: *Deviations from rate-of-return parity are mostly unaffected by the differences between the two assets.*

SUPPORT FOR RESULT 3: The estimates shown in column (1) of Table 5 indicate that deviations from rate-of-return parity in SdurDdiv and DdurSdiv are not significantly different from those in the baseline SdurSdiv. On the other hand, deviations in DdurDdiv are on average 13.44% (= −10.10 − 9.20 + 5.86) lower than in the baseline. Although this difference is statistically significant (χ^2 = 3.56, p-value = 0.0592), we cannot reject the hypothesis that SdurDdiv, DdurSdiv, and DdurDdiv have the same impact on deviations from rate-of-return parity at any conventional level (χ^2 = 1.04, p-value = 0.5933). ■

[Table 5: About Here]

4. Results for Differences in Institutional Regulations

Figures 5 and 6 provide the time series of median transaction prices and trading volumes in treatments Taxy and Holdy, respectively. Recall that, in terms of their intrinsic characteristics, X and Y were exactly the same assets in these two treatments. Nevertheless, the trading regulations imposed on Y—a transaction tax in Taxy and a minimum holding period in Holdy—made Y a more "restricted" asset than X. Therefore, it is not surprising to see from Figures 5 and 6 that less Y was traded than X in the market. But note that subjects in the benchmark SdurSdiv treatment also tended to trade more asset X than asset Y. So, it is not obvious if the transaction tax or minimum holding duration did influence Y's trading in any significant way. In fact, the regression analysis reported in section 4.1 below indicates that the two trading regulations have no significant impact on asset Y's turnover. Bubbles, comparable with those in SdurSdiv in their sizes, occurred in all markets in these two treatments. Also, like in SdurSdiv, prices of the two assets appear to be perfectly correlated. Therefore, the overall impression we get from these two treatments is that, as long as two assets' intrinsic characteristics are identical, the trading regulations imposed on asset Y are not strong enough to make investors differentiate between the two assets.

[Figures 5 and 6: About Here]

4.1 Treatment Effects on Price Amplitude and Turnover

The price amplitude, normalized average bias, normalized average deviation, and turnover of X and Y in Taxy and Holdy, shown in Table 2, are only slightly smaller than those in SdurSdiv. And if we compare the bubble measures between X and Y within the same treatment, it is clear that trading restrictions generate almost the same behavioral pattern as in the baseline treatment. That is, asset Y's price amplitude and normalized average bias are not much different from asset X's. Also, as in the baseline, the average normalized deviation of Y is much smaller than that of X. This result is mostly due to the fact that asset Y's turnover is, on average, 40%-50% lower than asset X's.

In the following, we utilize the same random-effects panel data approach as described above to investigate if a transaction tax or a minimum holding duration imposed on one asset has any influence on the price amplitude and turnover of either asset. The regression results are reported in Table 6.

[Table 6: About Here]

RESULT 4: *The transaction tax or the minimum holding duration imposed on asset Y has no significant impact on asset X's price deviation and turnover. Asset Y's turnover is marginally lower when the holding restriction is in effect. Overall, compared to the baseline treatment, the market is not significantly influenced by either institutional rule.*

SUPPORT FOR RESULT 4: The estimates shown in Table 6 indicate that, compared to the baseline SdurSdiv treatment, the transaction tax imposed on asset Y reduces not only asset Y's but also asset X's average price deviation and turnover. None of the reductions, however, is statistically significant. The minimum holding restriction has a very similar qualitative impact except that its influence on Y's turnover turns out to be marginally significant. ■

4.2 Treatment Effects on the Deviation from Rate-of-Return Parity

Column (2) of Table 4 reports the mean deviation of P_t^X / P_t^Y from the predication of rate-of-return parity in Taxy and Holdy. The same statistical summary from the baseline treatment (SdurSdiv) is also provided for direct comparisons. Also, since both assets have the same life duration of 30 periods in all three treatments, we employ the data from all periods when computing the averages.

On average, P_t^X / P_t^Y deviates from rate-of-return parity by about 7.18% and 8.72% per period in Taxy and Holdy, which do not appear to be much different from an average deviation of 7.88% in the baseline. Regression results summarized below provide further support to this observation.

RESULT 5: *The transaction tax or the minimum holding duration imposed on asset Y has no significant impact on the deviation of* P_t^X / P_t^Y *from the prediction of rate-of-return parity.*

SUPPORT FOR RESULT 5: Column (2) of Table 5 provides the estimates from GLS random-effects regressions. The estimate of the dummy variable Taxy being −0.70 implies that the deviation of P_t^X / P_t^Y from rate-of-return parity is on average 0.70% smaller than that in the baseline SdurSdiv treatment. Similarly, the estimate of Holdy is 0.84, indicating that, compared to the baseline treatment, the difference between the observed P_t^X / P_t^Y and the prediction is 0.84% larger. Neither estimate is statistically significant. ■

5. Arbitrage vs. Speculation

In this section, we investigate why bubbles are significantly smaller when two assets are different intrinsically than when they are not. We extend the concept used to construct a measure for short-term speculation by Hanke et al. (2010) and decompose each trader's whole trading sequence in any given period into the following four categories: same offer/same market, opposite offer/same market, same offer/different market, and opposite offer/different market. "Same offer/same market" means that two back-to-back purchases or back-to-back sales are being executed in the same market, whereas "opposite offer/same market" means that a purchase is followed by a sale (or vice versa) in the same market.[11] "Same offer/different market" and "opposite offer/different market" are defined similarly except that the two subsequent trades occur in different markets. The way that we decompose a trader's trading sequence is as follows. For instance, for a trader who makes five trades in a given period *t* with a trading sequence of first buying X, then buying X again, then selling X, then moving on to sell Y, and then finally buying Y, we would assign 1 to same offer/same market (buy X → buy X), 2 to opposite offer/same market (buy X → sell X and sell Y → buy Y), 1 to same offer/different market (sell X → sell Y), and 0 to opposite offer/different market. Then for each session, we sum up the points across all traders and all times periods for each single category *i* and divide category *i*'s total points by the sum of all four categories'. Table 7 provides the summary of these trading activities. It indicates that, for example, in the baseline SdurSdiv treatment, the probability that two adjacent trades occur in two different markets is, on average, 48% (= 33 + 15). Furthermore, given that one switches to a different market to trade, the probability that he will place an offer opposite to the previous one is about 31% (= 15/48).

[Table 7: About Here]

While it is almost impossible to verify the motive behind each single trade from the data, it is perhaps not unreasonable to assume that a sale immediately following a purchase (or vice versa) in a different market is more an act of arbitrage across assets. Therefore, we define the frequency of arbitrage across assets as the probability that two adjacent trades are of opposite offers, conditional on the fact that they take place in two different markets. This measure is reported in the third column from the right in Table 7.

[11] The term "offer" here concerns only the direction of a trade (buy or sell).

RESULT 6: *The existence of two intrinsically differentiated assets encourages more arbitrage conducted across markets and thus helps reduce the magnitude of bubbles.*

SUPPORT FOR RESULT 6: Taking each session as an independent observation, a non-parametric Mann-Whitney ranksum test rejects the hypothesis that the frequency of arbitrage across assets is independent of the assets being intrinsically different or not (p-value = 0.0120). In other words, the existence of two intrinsically differentiated assets does encourage traders to exploit mispricing across markets more frequently. To see if arbitrage helps reduce mispricing, we calculate the non-parametric Spearman rank correlation between the amplitudes of the two assets and the frequency of arbitrage across assets. The coefficient is –0.4031 (p-value = 0.0629) for asset X and –0.4036 (p-value = 0.0625) for asset Y, suggesting that the more frequently traders conduct arbitrage, the smaller bubbles are.[12] ■

For the measure of speculation, we follow Hanke et al. (2010) and consider, for example, a sale immediately following a purchase (or vice versa) within a given market as an act of short-term speculation. As a result, we define the frequency of short-term speculation in a given market as the probability that two adjacent trades are of opposite offers, conditional on the probability that they are executed in the same market. This measure is reported in the last two columns of Table 7.

RESULT 7: *The frequency of short-term speculation is independent of whether or not assets are intrinsically different. As a result, the frequency of short-term speculation does not explain why bubbles are smaller when two assets are intrinsically different than when they are not.*

[12] For the treatments in which asset Y lasts 15 periods, we use the amplitude of asset Y from the first half of the experiment where mispricing is more prominent. This is done to also avoid the impact of learning effects.

SUPPORT FOR RESULT 7: Taking each session as an independent observation, a non-parametric Mann-Whitney ranksum test cannot reject the hypothesis that the frequency of short-term speculation in either market is independent of the assets being intrinsically different or not (p-value = 0.2334 and 0.9474 for X and Y, respectively). The Spearman rank correlation coefficient between the bubble amplitude and the frequency of short-term speculation is 0.2562 for market X and 0.2560 for market Y. Neither coefficient is statistically significant (p-value = 0.2497 and 0.2502 for X and Y, respectively). ■

6. Conclusion

In this paper, we study if and how having two differentiated assets affects bubble formation. We consider differentiation that is caused by assets' intrinsic characteristics including their life durations and expected per period dividends. We also consider trading regulations such as a transaction tax and a minimum holding period requirement that have been considered by some as policy tools that would curb speculation and reduce asset mispricing. We impose these trading regulations only on one of the two markets to help differentiate two otherwise identical assets. We find that, compared to trading regulations, differences in assets' intrinsic characteristics tend to encourage more arbitrage across assets and thus help reduce mispricing significantly. We also find that short-term speculation does not depend on how assets or markets are being differentiated, and that the correlation between short-term speculation and bubble amplitude is statistically insignificant. In other words, the smaller bubbles that we observe in treatments SdurDdiv, DdurSdiv, and DdurDdiv are more likely to be the consequence of more arbitrage, not less speculation. Overall, these results suggest that, to mitigate bubbles and improve market efficiency, providing investors a more diversified investment environment may be a more effective than imposing trading regulations.

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Table 1: Summary of Treatments and Sessions

Treatment	Session	# of Subjects	Expected Dividend		Life Duration		Trans-action Tax		Holding Period	
			X	Y	X	Y	X	Y	X	Y
SdurSdiv (*baseline*)	SdurSdiv1	10	7	7	30	30				
	SdurSdiv2	9								
	SdurSdiv3	10								
	SdurSdiv4	10								
SdurDdiv	SdurDdiv1	9	7	14	30	30				
	SdurDdiv2	10								
	SdurDdiv3	10								
DdurSdiv	DdurSdiv1	10	7	7	30	15				
	DdurSdiv2	10								
	DdurSdiv3	9								
	DdurSdiv4	10								
DdurDdiv	DdurDdiv1	10	7	14	30	15				
	DdurDdiv2	9								
	DdurDdiv3	10								
Taxy	Taxy1	10	7	7	30	30		√		
	Taxy2	9								
	Taxy3	10								
	Taxy4	10								
Holdy	Holdy1	10	7	7	30	30				√
	Holdy2	10								
	Holdy3	10								
	Holdy4	10								

Table 2: Observed Bubble Measures in All Treatments

Treatment	Amplitude			Normalized Average Bias			Normalized Average Deviation			Average Turnover		
	X	Y1	Y16	X	Y1	Y16	X	Y1	Y16	X	Y1	Y16
SdurSdiv	1.44	1.37		0.48	0.42		0.150	0.084		0.26	0.18	
SdurDdiv	0.37	0.55		0.04	0.08		0.010	0.017		0.09	0.11	
DdurSdiv	0.20	0.27	0.20	0.03	0.07	0.03	0.006	0.026	0.011	0.13	0.16	0.14
DdurDdiv	0.33	0.30	0.27	0.09	0.12	0.04	0.020	0.019	0.011	0.15	0.16	0.19
Taxy	1.00	1.05		0.43	0.41		0.107	0.065		0.21	0.11	
Holdy	1.20	1.12		0.39	0.36		0.076	0.048		0.17	0.10	

Table 3: Effects of Intrinsic Differences on Assets' Price Deviation ($\left|P_t^i - f_t^i\right| \big/ f_1^i$)and Turnover ($q_t^i \,/\, TSU^i$)

	Asset X (Periods 1-30)		Asset Y (Periods 1-15)		Overall Market (Periods 1-15)	
	(1) Price Deviation (in %)	(2) Turnover (in %)	(3) Price Deviation (in %)	(4) Turnover (in %)	(5) Price Deviation (in %)	(6) Turnover (in %)
Constant	41.71*** (8.22)	32.32*** (6.21)	30.02*** (5.25)	27.16*** (5.28)	27.36*** (4.71)	32.49*** (5.62)
Period	0.54*** (0.15)	–0.42*** (0.06)	0.88*** (0.21)	–0.33* (0.18)	1.05*** (0.17)	–0.61*** (0.14)
Ddiv	–43.49*** (12.07)	–16.59* (9.38)	–23.50*** (7.61)	–10.74 (7.78)	–24.67*** (6.89)	–15.16* (8.43)
Ddur	–46.29*** (11.17)	–12.53 (8.68)	–28.56*** (7.05)	–8.47 (7.20)	–29.01*** (6.38)	–12.28 (7.80)
Ddiv * Ddur	49.74*** (17.07)	18.53 (13.26)	27.02*** (10.76)	10.62 (11.00)	27.96*** (9.74)	17.34 (11.92)
Obs.	420	420	210	210	210	210

*** and *: significant at the 1% and 10% levels, respectively. Standard errors are in parentheses.

Table 4: Mean Deviation of P_t^X / P_t^Y from $(P_t^X / P_t^Y)^*$ (in %)

Treatment	(1) Periods 1 - 15	(2) Periods 1 - 30
SdurSdiv	5.82 (20.18)	7.88 (22.13)
SdurDdiv	−4.28 (11.17)	
DdurSdiv	−3.38 (18.51)	
DdurDdiv	−7.63 (32.96)	
Taxy		7.18 (37.60)
Holdy		8.72 (35.79)

Standard deviations are in parentheses.

Table 5: The Feasible GLS Estimates of Treatment Effects on $(P_t^X / P_t^Y) - (P_t^X / P_t^Y)^*$ (in %)

	(1) Periods 1 - 15	(2) Periods 1 - 30
Constant	5.29 (5.37)	−1.58 (4.97)
Period	0.07 (0.33)	0.61*** (0.19)
Ddiv	−10.10 (7.13)	
Ddur	−9.20 (6.60)	
Ddiv * Ddur	5.86 (10.08)	
Taxy		−0.70 (5.60)
Holdy		0.84 (5.60)
Number of Observations	210	360

***: significant at the 1% and 10% levels, respectively. Standard errors are in parentheses.

Table 6: Effects of Institutional Differences on Assets' Price Deviation ($\left|P_t^i - f_t^i\right| \big/ f_1^i$)and Turnover ($q_t^i / TSU^i$)

	Asset X (Periods 1-30)		Asset Y (Periods 1-30)		Overall Market (Periods 1-30)	
	(1) Price Deviation (in %)	(2) Turnover (in %)	(3) Price Deviation (in %)	(4) Turnover (in %)	(5) Price Deviation (in %)	(6) Turnover (in %)
Constant	32.22*** (13.42)	32.35*** (6.66)	32.99*** (12.31)	21.62*** (3.55)	32.61*** (12.84)	26.98*** (4.89)
Period	1.15*** (0.23)	−0.42*** (0.09)	0.85*** (0.21)	−0.23*** (0.06)	1.00*** (0.22)	−0.33*** (0.06)
Taxy	−6.01 (18.30)	−4.94 (9.22)	−3.58 (16.78)	−6.81 (4.83)	−4.80 (17.51)	−5.88 (6.78)
Holdy	−8.35 (18.30)	−8.60 (9.22)	−6.49 (16.78)	−8.35* (4.83)	−7.42 (17.51)	−8.48 (6.78)
Number of Groups	12	12	12	12	12	12
Number of Observations	360	360	360	360	360	360

*** and *: significant at the 1% and 10% levels, respectively. Standard errors are in parentheses.

Table 7: Categories of Trading Activities

Session	Same Offer	Opposite Offer	Same Offer	Opposite Offer	Frequency of Arbitrage across Assets	Frequency of Short-Term Speculation in Mkt X	Frequency of Short-Term Speculation in Mkt Y
	Same Market		Different Market				
SdurSdiv	28%	24%	34%	15%	32%	47%	44%
SdurDdiv	36%	21%	24%	18%	43%	39%	36%
DdurSdiv	36%	19%	26%	19%	43%	39%	30%
DdurDdiv	49%	19%	16%	15%	48%	31%	28%
Taxy	41%	22%	27%	10%	29%	39%	27%
Holdy	39%	19%	28%	14%	35%	34%	26%

Figure 1: SdurSdiv Treatment

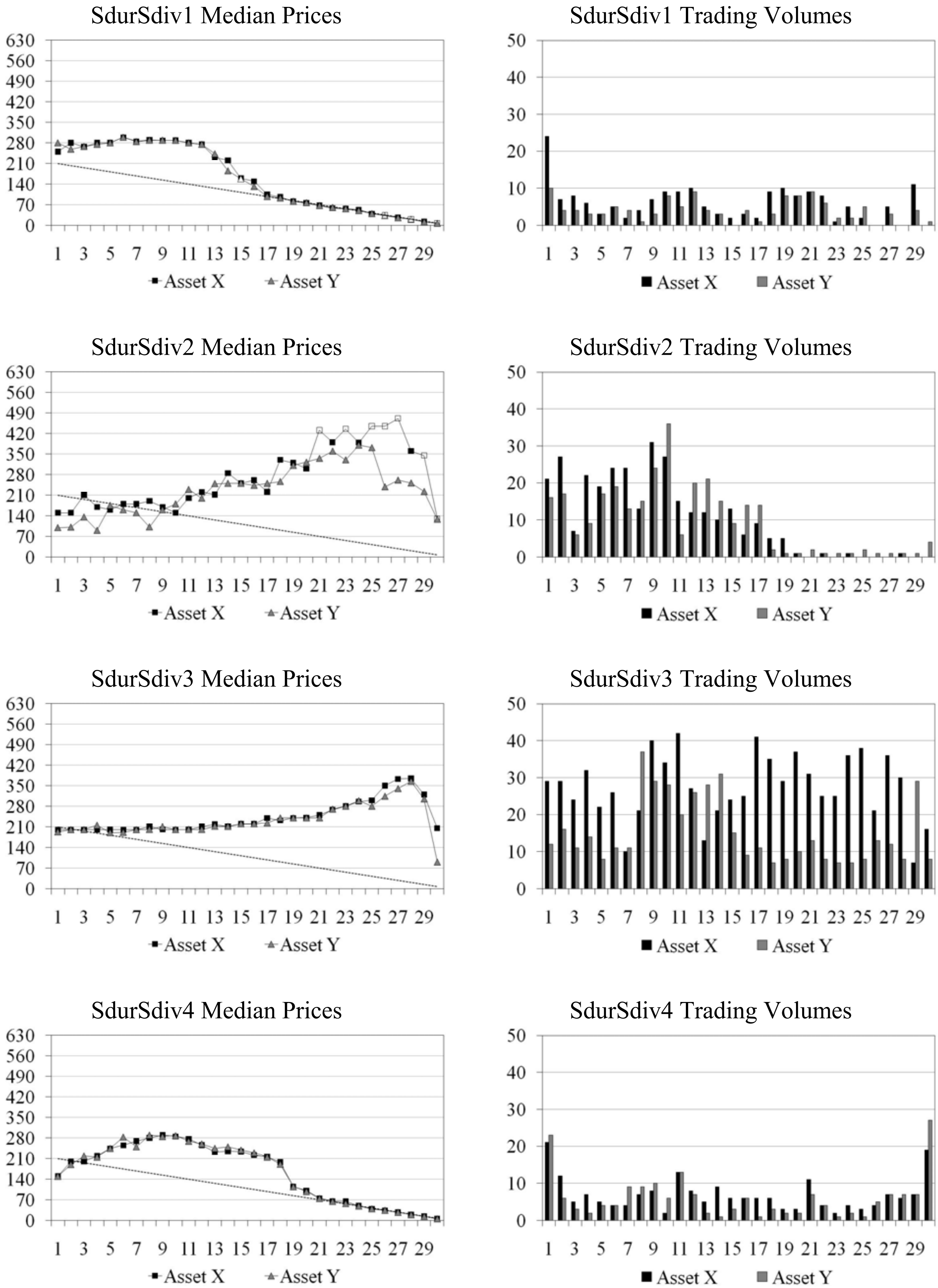

Figure 2: SdurDdiv Treatment

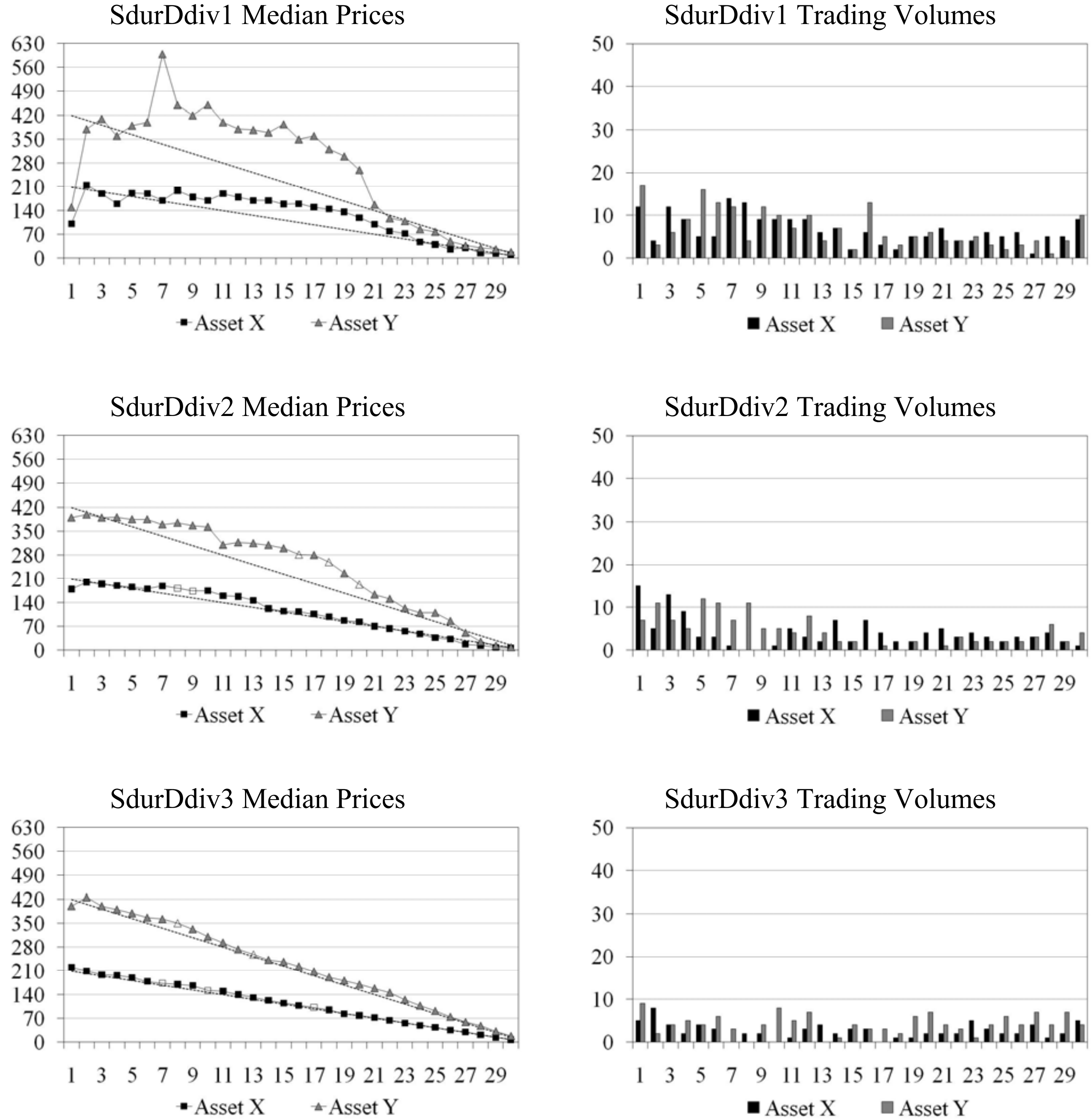

Figure 3: DdurSdiv Treatment

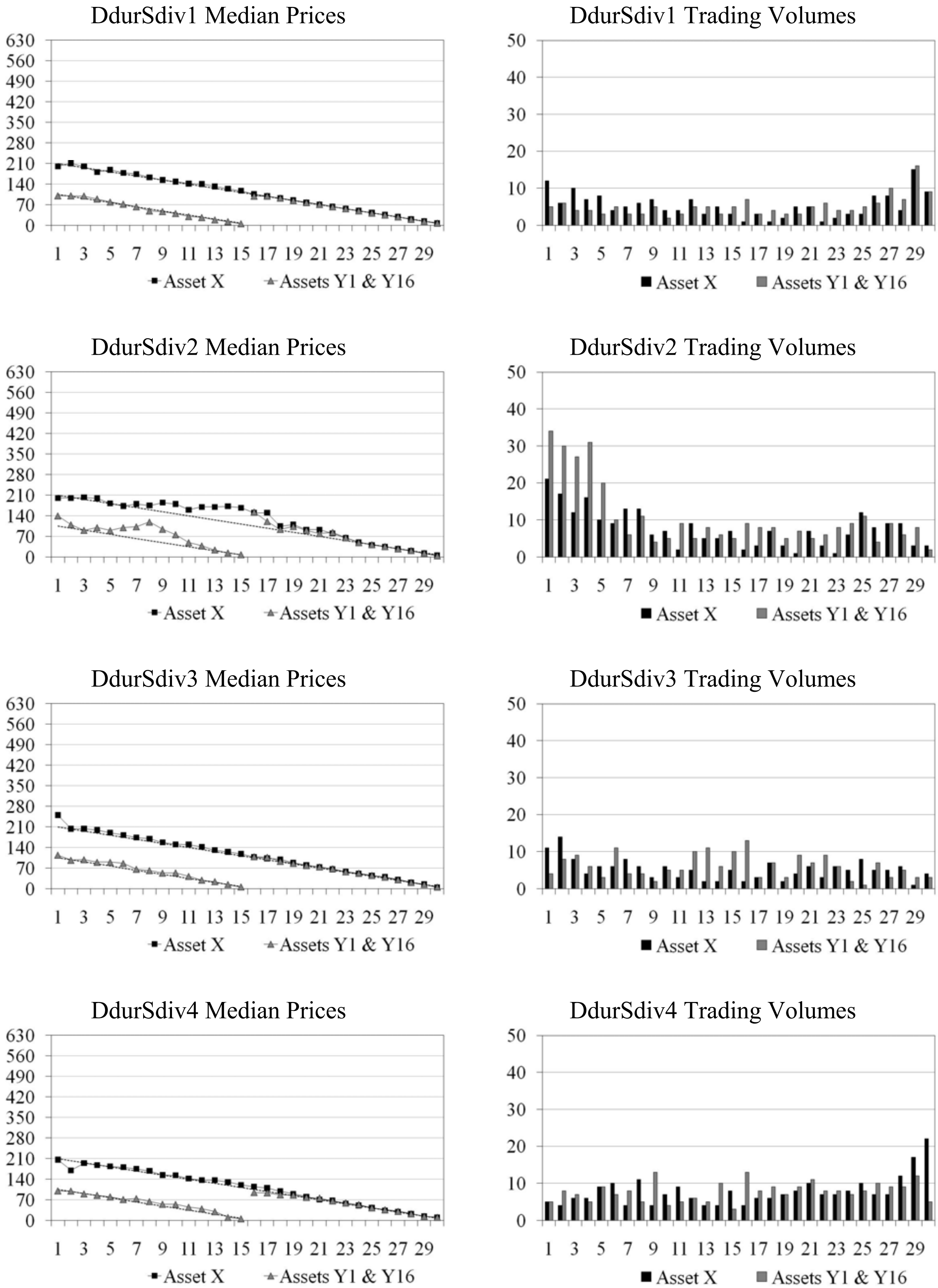

Figure 4: DdurDdiv Treatment

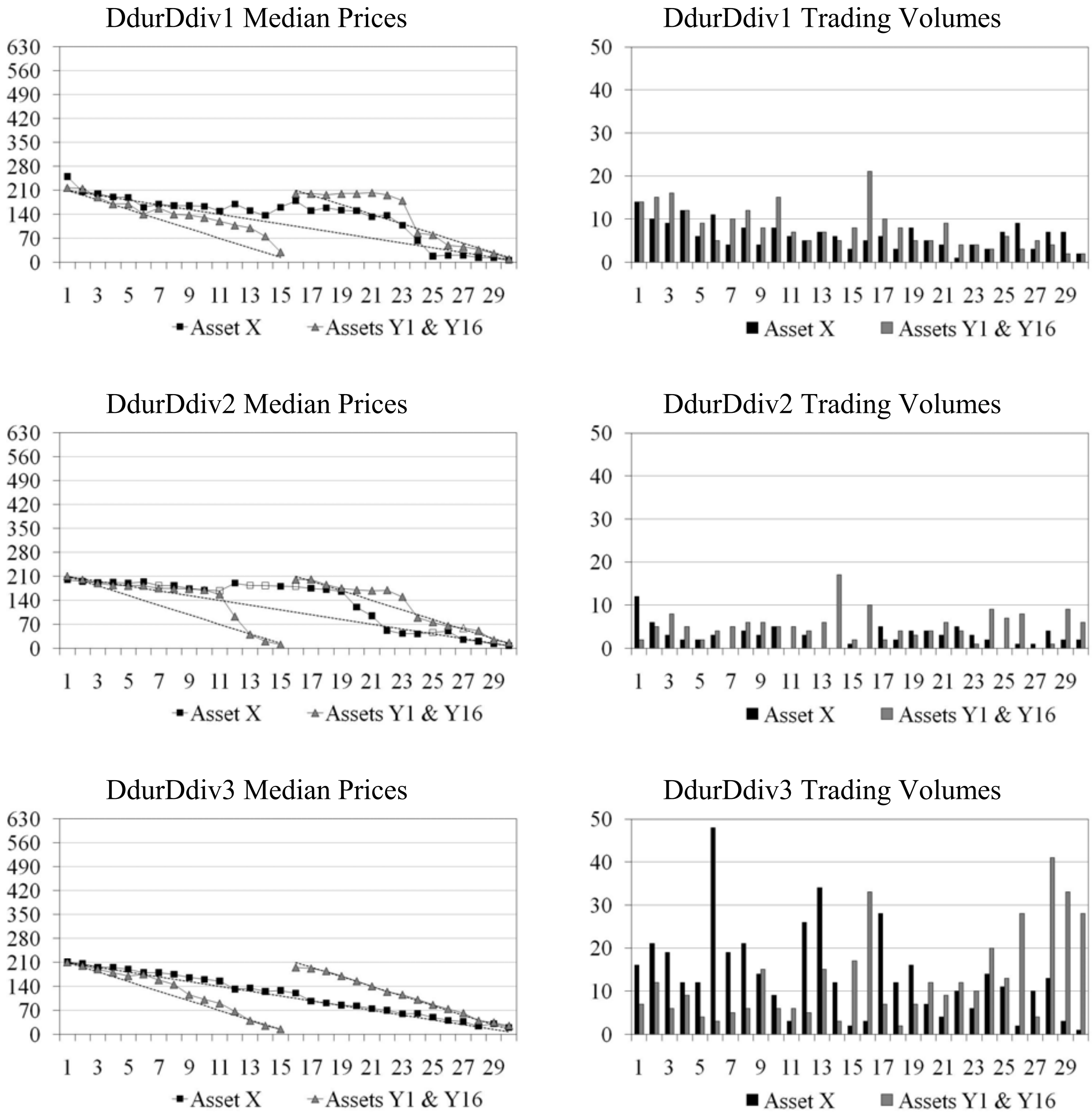

Figure 5: Taxy Treatment

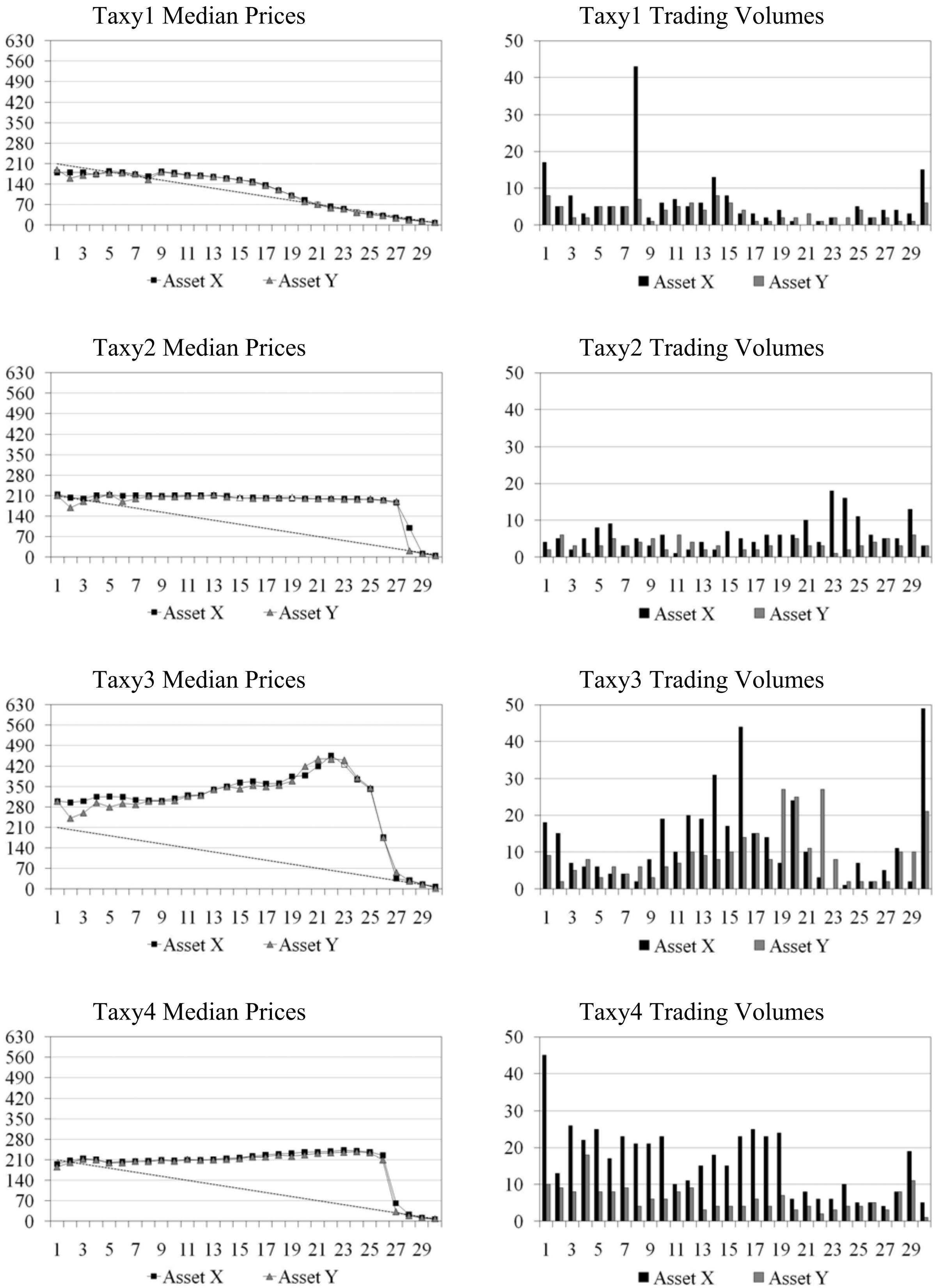

Figure 6: Holdy Treatment