DISCUSSION PAPER SERIES

IZA DP No. 5704

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Stephen L. Cheung
Andrew Coleman

May 2011

Forschungsinstitut
zur Zukunft der Arbeit
Institute for the Study
of Labor

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Stephen L. Cheung
University of Sydney
and IZA

Andrew Coleman
University of Sydney

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IZA

P.O. Box 7240
53072 Bonn
Germany

Phone: +49-228-3894-0
Fax: +49-228-3894-180
E-mail: iza@iza.org

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May 2011

ABSTRACT

League-Table Incentives and Price Bubbles in Experimental Asset Markets*

We study experimental markets in which participants face incentives modeled upon those prevailing in markets for managed funds. Each participant's portfolio is periodically evaluated at market value and ranked in a league table according to short-term paper returns. Those who rank highly attract a larger share of new fund inflows. Under conditions in which prices are close to intrinsic value, the effect of incentives is mild. However under conditions in which markets are prone to bubble, mispricing is greatly exacerbated by incentives. Even in experienced markets, prices climb to levels clearly indicative of speculation and do not always crash back.

JEL Classification: C92, G12, M52

Keywords: league tables, price bubbles, managed funds markets, tournament incentives, asset market experiments

Corresponding author:

Stephen L. Cheung
School of Economics
University of Sydney
Merewether Building H04
Sydney NSW 2006
Australia
E-mail: Stephen.Cheung@sydney.edu.au

* We thank Charles Noussair and Robert Slonim for suggestions toward our design, and Stefan Palan for programming advice. We also thank seminar audiences at the University of Graz and University of Sydney, and participants at the 2010 Asia-Pacific Meetings of the Economic Science Association in Melbourne, the 2010 World Meetings of the Economic Science Association in Copenhagen, the 2010 Australian Conference of Economists in Sydney, and the 2010 International Workshop on Experimental Economics and Finance in Xiamen. Financial support from the University of Sydney is gratefully acknowledged. Portions of this paper were completed while Stephen Cheung was visiting the Institute for Banking and Finance at the University of Graz, the Agricultural and Resource Economics group at the University of Sydney and CentER at Tilburg University, and he thanks them for their hospitality.

INTRODUCTION

In the aftermath of the global financial crisis of 2008, the compensation and incentive structures of participants in financial markets have come under intense scrutiny in regulatory and policy circles. Of particular interest in these discussions is the question of whether market participants face incentives that may induce them to behave in a manner that might contribute to the distortion or instability of markets. One specific channel through which this may occur has been canvassed in recent research on managed funds. According to this argument, "returns-chasing" retail investors respond to rankings information on the relative performance of competing funds. As a result, funds that rank highly in the "league table" attract the lion's share of new fund inflows. Since fund managers are typically remunerated as a function of funds under management, their incentives will thus have tournament characteristics. Thus they may be tempted to pursue short-run strategies directed toward improving a fund's position in the league table, potentially to the detriment of the long-run interests of existing investors (Brown, Harlow and Starks 1996, Chevalier and Ellison 1997).

Well-known examples of agencies that compile rankings of the relative performance of mutual funds include Morningstar, Inc. and Lipper, Inc. Such rankings information is readily accessible to retail investors through a very wide variety of media and online outlets. The empirical relationship between a fund's recent performance and new inflows into that fund has been extensively documented in numerous studies.[1] Of course, whether returns-chasing behavior is rational for investors depends upon the degree to which there is persistence in fund performance over time. While this is itself an empirical question, the dissemination of performance information is typically accompanied by the disclaimer that past returns are not necessarily indicative of future returns. Finally, the extent to which funds are observed to distort their risk profile in response to league-table incentives in field data has also been the subject of a lively empirical debate.[2]

While this literature has been concerned with the effect of relative performance rankings on the strategies of individual funds, it is silent on the question of the aggregate implications of league-table incentives for the performance of the market as a whole. Further, it is important

[1] See, for example, Ippolito (1992), Patel, Zeckhauser and Hendricks (1994), Goetzmann and Peles (1997), Sirri and Tufano (1998), Del Guercio and Tkac (2002), and Ivković and Weisbenner (2009). Del Guercio and Tkac (2008) provide direct evidence on the effect of Morningstar ratings.

[2] See, for example, Brown, Harlow and Starks (1996), Chevalier and Ellison (1997), Koski and Pontiff (1999), Busse (2001), Goriaev, Nijman and Werker (2005), Chen and Pennachi (2009).

to stress that the relative performance that drives fund inflow is necessarily assessed on the basis of paper returns evaluated at market prices. These market valuations need not coincide with a fund manager's own judgment of the "true" intrinsic value of a fund's assets.

If market conditions are such that there are strong forces that work to keep prices close to intrinsic value, then there is little prospect that a fund can improve its relative performance other than by trading on "fundamentals" – in effect seeking to arbitrage price deviations from intrinsic value more successfully than its competitors. However when the market is in a bubble, this is no longer the case. Since it is performance evaluated at market prices that drives new fund inflows, a manager's incentive to rank highly in terms of paper returns may overwhelm considerations of intrinsic value. A fund may then "ride the bubble" by betting that prices the manager considers to be overvalued will nonetheless continue to rise. It does this because the manager fears that if the fund sells out of the bubble prematurely it will lag the performance of its competitors in the short term, and thereby suffer reduced inflows.

In this paper, we examine whether league-table incentives may contribute to the perpetuation of price bubbles in asset markets. A bubble in asset prices has been defined as "trade in high volumes at prices that are considerably at variance from intrinsic value" (King et al 1993, p. 183). Such an event, and any ensuing crash back to intrinsic value, can have adverse consequences for the efficient allocation of capital, as well as distorting the distribution of wealth and propagating instability throughout the economy. For these reasons, the factors that contribute to the severity of price bubbles are of interest to policy makers and regulators.

Numerous historical episodes of extreme pricing behavior have been put forward as instances of bubbles – foremost among these are the Dutch "Tulipmania" of the seventeenth century and the pricing of technology stocks at the turn of the twenty-first century. However, an inherent difficulty of studying price bubbles using historical data is that an asset's true intrinsic value is not observable even in retrospect. Thus any empirical assessment of a price bubble is necessarily contingent upon assumptions that must be made with regard to intrinsic value, leading to the possibility of specification error. As a result, there is always scope for disagreement over whether any given historical episode indeed constitutes a price bubble.[3]

[3] For a reappraisal of the Dutch "Tulipmania" see Thompson (2006). For the case of technology stocks see Pástor and Veronesi (2006).

For the purpose of studying the effect of incentive structures upon price bubbles, a further challenge for empirical research is that the incentives facing market participants may be endogenous to the performance of the market under consideration, may differ between participants within a given market, and may in any case not be observable to the researcher.

In this paper, we study empirically the effect of league-table incentives upon the severity of price bubbles in asset markets, by comparing the performance of markets in which such incentives are present to ones in which they are absent. Our solution to the challenges raised in the preceding paragraphs is to make this comparison in the context of a laboratory experiment. In this setting, both the intrinsic value of the asset that is bought and sold and the incentives facing market participants are known and under the control of the researcher. This enables us to obtain a clean identification of the causal effect of the incentive structure, holding all other aspects of the market environment constant.

The specific parametric design of our experiments is based upon canonical studies by Smith, Suchanek and Williams (1988) and Noussair, Robin and Ruffieux (2001). The key features of this design include: an asset with a known and finite lifetime, periodic dividends that are independent draws from a known probability distribution, common knowledge of all payoff-relevant information, and repetition of the entire multi-period market. We adopt this framework because it is a proven design whose properties are well-known, extensively replicated, and found to be robust to a variety of manipulations in an extensive body of previous research.[4] Further, there also exists a broadly-accepted set of measures for evaluating the performance of markets of this type, enabling our results to be interpreted within the context of the existing literature.

Each experimental market consists of nine traders who can buy and sell an asset in continuous time. Since individual transaction prices – as well as the behavior of individual participants within a given market – are likely to be interdependent in complex ways, we focus on the market itself as the unit of independent observation and conduct our analysis in terms of market-level measures of performance. In other words, our primary focus is the effect of league-table incentives upon the severity of price bubbles at a market level, as opposed to the intermediating effects of incentives upon individual behavior.

[4] See, for example, King et al (1991), van Boening, Williams and LaMaster (1993), Porter and Smith (1995), Caginalp, Porter and Smith (2001), Lei, Noussair and Plott (2001), Dufwenberg, Lindqvist and Moore (2005), Haruvy and Noussair (2006), Haruvy, Lahav and Noussair (2007), and Hussam, Porter and Smith (2008).

In our baseline experiments, each trader receives identical periodic bonuses irrespective of their performance. These bonuses model the inflow of new funds under management, and in the baseline they do not vary as a function of relative performance. Thus under the baseline, a trader's earnings depend only upon the intrinsic value of their holdings at the conclusion of the market. In our tournament condition, we introduce league-table incentives by allocating bonuses on the basis of each trader's relative performance, as measured by the recent growth in the paper value of their portfolio. Once again, final earnings are assessed at intrinsic value; however the measure of return that is used to construct the league table is based upon market price. In this manner, we induce a tension between the pursuit of long-run and short-run measures of value under the tournament.

In addition to this primary treatment dimension, we also consider the effect of experience in repeated markets, and of varying the parameterization of intrinsic value. We do this because the standard design of an experimental asset market, in which intrinsic value declines over time, has been observed to bubble even in the absence of league-table incentives. Such bubbles, however, are also known to robustly diminish with experience. By studying repeated markets, we can examine whether the effect of league-table incentives is powerful enough to counteract the tendency for prices to track more closely to intrinsic value with experience. By also studying an alternative environment in which intrinsic value is constant over time, which is known to be less bubble prone, we can examine whether the effect of incentives is milder under conditions in which the tension between market and intrinsic value is less pronounced. Our results are consistent with both of these conjectures.

In the standard (declining-value) environment with baseline incentives, we replicate the results of previous studies: we observe a tendency for prices to deviate above intrinsic value, but this moderates with experience in repeated markets. As discussed above, we expect the effect of league-table incentives to be more pronounced in an environment in which market and intrinsic values deviate persistently from one another. Consistent with this, we find that price deviations above intrinsic value are significantly larger under league-table incentives than in the baseline. Moreover, under league-table incentives, the magnitude of price bubbles is significantly *exacerbated* with experience. This contrasts with previous findings on the effect of experience upon mispricing in experimental asset markets, and confirms the potential for league-table incentives to amplify price distortions in these markets.

In the constant-value environment with baseline incentives, we again observe that prices deviate somewhat above intrinsic value in inexperienced markets. However, and again consistent with previous research, these deviations are mild compared to what we observe in the declining-value environment. Moreover, in experienced markets with baseline incentives, prices track intrinsic value almost perfectly.[5] Accordingly, we expect the effect of league-table incentives to be less pronounced in this environment: since the tension between market and intrinsic values is less severe, there is less scope for a trader to improve their relative position by deviating from the pursuit of intrinsic value. We find that prices are nonetheless significantly higher under league-table compared to baseline incentives and, moreover, that the difference persists with experience. However, the effect of incentives is much milder than in the declining-value environment, manifesting itself in the form of sustained overpricing by a factor of around five percent relative to intrinsic value.

RELATED LITERATURE

We are aware of related experimental work by James and Isaac (2000) and Isaac and James (2003). They study experimental asset markets in which above-average performers are paid as a function of the extent to which they "beat the market", while those who perform below average are simply paid a flat fee. This incentive structure is found to cause prices to diverge from intrinsic value. James and Isaac (2000) provide numerical examples of how their incentives can lead to rational trades at prices that depart from intrinsic value. However these examples are driven by the fact that under their incentives, the earnings of a trader who underperforms the market are *completely unhinged from the intrinsic value* of that trader's holdings. This explains why a trader who trails the market as the reporting date approaches could be indifferent to "throwing away" money on a bid that exceeds intrinsic value.

In the James and Isaac tournament, a trader's incentive payment is determined solely by their final position at the conclusion of fifteen trading periods. As a result, a trader who makes poor decisions early in the experiment may find themself so far out of the reckoning as to simply "give up" and resign themself to receiving the flat fee. We conjecture that this may account for the "frustration trades" noted by James and Isaac (2000, p. 1002).

5 We provide what we believe are the first reported results for repeated markets with constant intrinsic value. Our finding that (under baseline incentives) prices in this environment track intrinsic value more or less perfectly in experienced markets is of independent interest for the literature on experimental asset markets.

The design of our tournament condition addresses each of these concerns. Firstly, to ensure that earnings are ultimately aligned with long-run intrinsic value, we follow standard practice in the literature by paying out the final value of each trader's cash balance after all dividends have been realized. Secondly, to avert the possibility that some traders might become discouraged from competing over tournament incentives, we offer four equal-sized bonuses, at evenly-timed intervals over the life of the market. We design these bonuses such that no trader is ever out of contention for a bonus in the current "market year" on account of poor performance in previous years. Finally, we also note that our analysis of incentive effects is based upon a between-groups comparison, whereas James and Isaac report within-group comparisons that may be confounded by experience and treatment order.

We are also aware of related work by Robin, Strážnická and Villeval (2010). Their design is concerned with the frequency with which bonuses are paid to the top performers in a market. In their long-term bonus treatment, similar to James and Isaac, bonuses are paid only once – upon conclusion of fifteen periods of trade. In the short-term bonus treatment, bonuses are awarded after every trading period. In both treatments, bonuses are awarded to the top three performers out of a total of eight traders in each market.

In the long-term bonus condition, each trader's performance is evaluated on the basis of the overall change in their *cash position* over the life of the market. By contrast, in the short-term bonus condition, performance is assessed according to the change in the *paper value* of a trader's portfolio over the preceding period. Thus in the long-term condition, a trader's final share holdings at the end of the experiment are correctly ascribed their terminal intrinsic value of zero. On the other hand, in the short-term condition, a trader's share holdings at the end of each period are valued at market prices (using the average transaction price in the period just concluded).

We conjecture that this difference between the two conditions in how shares are valued in the assessment of performance may have a considerable bearing upon the results. Robin, Strážnická and Villeval find that relative to a baseline condition in which there are no bonuses, market prices are less distorted under long-term bonuses, whereas prices are more distorted under short-term bonuses. We interpret their result to be consistent with our intuition that the effect of incentives will be distortionary specifically when the incentives induce a tension between the pursuit of market and intrinsic values. However, the magnitude of the effects they report are modest, and they do not consider the effect of experience. By contrast, our central finding concerns the interaction of incentives with experience, as we show that the effect of incentives upon mispricing is exacerbated with experience.

DESIGN

Overview

Our experimental design has three dimensions. Our primary objective is to identify the effect upon market performance of a league-table incentive regime in which market participants compete over new fund inflows that accrue as a function of their past relative performance ranking, and where performance is assessed on the basis of paper returns. To this end, we compare a baseline condition, in which new inflows accrue uniformly irrespective of performance, to a tournament condition in which they depend upon relative returns, in a manner that will be made precise below.

In addition to this primary treatment manipulation, we examine the robustness of incentive effects with respect to two additional dimensions. Firstly, we examine how the effect of the incentive structure interacts with market experience, by completing two repetitions of the market in each session. Secondly, we implement two alternative parameterizations of the dividend process that gives rise to the intrinsic value of the experimental asset. We refer to this latter dimension hereinafter as the "market environment". Our analyses of the effect of the incentive condition and market environment are based upon between-group comparisons, while we identify the effect of experience in a within-group comparison.

Parameters common to all treatments

We begin by documenting those features of the design that are common across all sessions of our study. Our unit of observation is a market, with each market composed of nine traders. Each repetition of a market operates for sixteen trading periods. At the start of the first period each trader is given an initial endowment of experimental money and shares. All nine traders receive the exact same endowments, and thus have identical *ex ante* earnings opportunities.

In each trading period, the market opens for three minutes during which traders can buy and sell shares in exchange for money in a computerized continuous double auction market. At the end of each period, each share pays a stochastic dividend to its current owner. This dividend is the same for all shares in the market in any given period, and is added to the owner's money balance at the end of the period.[6] A trader's holdings of money and shares carry over from one trading period to the next within a given market repetition.

In every treatment, the instructions include an "average holding value table" which summarizes, for each of the sixteen periods, the sum of the expected dividends that a trader would receive on average from each share if it were held from the current period through until the end of the sixteenth period. Since this information is provided to all traders in the market, *the intrinsic value of shares is common knowledge throughout the entire experiment*.

We frame a single trading period as a "market quarter" and a set of four consecutive trading periods as a "market year". Each sixteen-period market repetition thus constitutes four market years. At the conclusion of the first ("inexperienced") market repetition, all money and share balances are reinitialized to their starting values, and a second ("experienced") repetition is conducted. Participants are paid for their decisions in both repetitions, according to their closing money balance after the final dividend has accrued.[7] This amount is converted into cash at a fixed and pre-announced exchange rate and paid at the conclusion of the session.

The Smith and Noussair market environments

To the best of our knowledge, ours is the first study in the extensive literature on experimental asset markets to examine the effect of a given treatment condition – here, league-table incentives – across two distinct market environments. We consider this an important feature of our design, and comment further on our rationale for so doing below.

The first environment, in which intrinsic value declines over the life of the asset, is due to Smith, Suchanek and Williams (1988), hereinafter SSW, and we refer to it as a "Smith market". This constitutes the canonical design for virtually all subsequent experimental research on asset markets – including the related studies of incentives by James and Isaac (2000), Isaac and James (2003) and Robin, Strážnická and Villeval (2010). Accordingly, we consider this to be the primary setting in which we examine the effect of incentives.

6 As explained below, in a "Noussair" market it is possible for the dividend to be negative. In this case, it is framed as a "holding cost", and subtracted from the owner's money balance at the end of the period.

7 In the case of the "Noussair" market environment, this is also after all shares have paid out their final redemption value, as will be explained below.

However, notwithstanding its benchmark status in the literature, the Smith design has not been entirely free from criticism.[8] Chief among its idiosyncrasies are the fact that the intrinsic value of shares declines over time and, relatedly, that the ratio of the volume of cash to the intrinsic value of stock increases over the life of the market. Both of these features are thought to contribute to the most striking feature of the Smith design, namely its tendency to generate price bubbles and crashes in markets in which participants are inexperienced.

For our purpose of studying the potential for incentives to distort market outcomes, this tendency of Smith markets to bubble is a double-edged sword. On the one hand, it creates conditions in which there is tension between market and intrinsic values, which we conjecture to be a prerequisite for league-table effects. On the other hand, it obliges us to disentangle the marginal distortion due to incentives from that which is inherent in the design of the market. It is for this reason that we introduce experience as a second dimension of our design.

Just as inexperienced Smith markets are known to bubble and crash, it is equally well-known that this tendency is attenuated with experience.[9] Thus by collecting both inexperienced and experienced observations on each of our markets we are able, firstly, to examine whether the effect of league-table incentives is itself either attenuated or exacerbated by experience, and secondly, to compare market performance under these incentives to a baseline in which the tendency of the environment to bubble has been moderated by experience. In effect, then, *we identify incentive effects in Smith markets through their interaction with experience*.

In light of these complications, we perform an additional robustness check by also examining the effect of our incentive structure in an alternative market environment due to Noussair, Robin and Ruffieux (2001), which we refer to hereinafter as a "Noussair market". In this design, the intrinsic value of shares remains constant over time, as does, on average, the ratio of cash to the intrinsic value of stock. As a result, this market has been found to be less prone to bubble and crash, although it is not considered entirely bubble-free. Accordingly, the conflict between market and intrinsic values is less pronounced in this environment, and we expect the distorting effects of league-table incentives to be less severe.

8 See, for example, Kirchler, Huber and Stöckl (2009).

9 See SSW (1988), van Boening, Williams and LaMaster (1993), Dufwenberg, Lindqvist and Moore (2005).

Smith market parameters

To accommodate our framing in terms of market quarters and years, we extend the life of the experimental asset from fifteen periods in SSW to sixteen. Following SSW, the dividend that is paid after each trading period takes values of 0, 8, 28 or 60 experimental currency units (ECU), each with equal probability, such that the expected dividend in each period is 24. At the end of the sixteenth period, all shares expire and have no further value. The intrinsic value of a share in any given period is thus 24 times the number of outstanding dividends. In particular, it is 384 in the first period, and declines by 24 after each dividend realization.

Whereas the traders in SSW's markets have heterogeneous initial endowments, we instead give all traders the same endowment, consisting of 2,496 ECU and eight shares. We do this to eliminate any possibility that the cash and share composition of a trader's initial endowment might influence their position in our tournament condition.[10, 11] In fixing the cash component of this endowment, we take care to ensure that the ratio of cash to the intrinsic value of stock is the same in the first period of our design as the corresponding value in SSW,[12] so as to facilitate comparison of our results with other research on markets of this type. This ratio increases over the life of a Smith market, as new dividend flows inject more cash into the market at the same time as the intrinsic value of shares declines.

Noussair market parameters

In the Noussair environment the intrinsic value of a share remains constant in every period. This is achieved by specifying the dividend process in such a way that the expected dividend in each period is equal to zero. In particular, the dividend takes values of −24, −16, 4 or 36, each with equal probability, where these represent the corresponding values in the Smith design shifted downward by their expected value of 24. Negative dividends are framed as "holding costs". So as to bestow shares with a positive intrinsic value, each share also pays a final redemption value of 400 after the end of the sixteenth period. The intrinsic value of a share is thus constant and equal to 400 in every period.

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10 With heterogeneous endowments, a trader who is initially endowed with more shares and less cash could, for example, rank more highly in the league table simply as a result of favorable dividend realizations.

11 King et al (1993) find that giving all traders equal initial endowments does not affect the tendency for Smith markets to bubble and crash.

12 That is, $2{,}496 / (384\times8) = 0.8125$. For the median trader in SSW, the corresponding calculation is $585 / (360\times2) = 0.8125$.

Because the expected dividend inflow to the market is zero in every period, the ratio of cash to the intrinsic value of stock is on average constant over the life of a Noussair market.[13] We set the initial ratio to 2:1 to make it comparable to the middle periods of a Smith market.[14] Thus we endow each trader in our Noussair markets with 6,400 ECU and eight shares.

The baseline and tournament incentive conditions

Our primary treatment manipulation is a tournament condition in which: 1) the value of traders' portfolios are periodically evaluated at market prices, 2) traders are ranked at the end of each market year (four trading periods) on the basis of the year-on-year growth in the paper value of their portfolios, and 3) at the end of each year each trader receives an inflow of new money and shares, the size of which depends upon their rank over the past year. We compare this to a baseline condition in which the first two features are absent, and all traders receive the same new inflow irrespective of their past performance.

Baseline incentive parameters

In our baseline sessions, every trader receives the same inflow of new money and shares at the end of each market year. Valued at intrinsic value, the size of each inflow is equivalent to one-quarter of the initial endowment. Since there are four such inflows, the total value of money and shares under management thus doubles over the sixteen-period life of the market.

The reason why we infuse new shares as well as money is to avoid distorting the ratio of cash to stock that would otherwise prevail in the market in the absence of any inflows. If we were to infuse new money alone, this could have an inflationary effect upon the share price for reasons of excess liquidity alone (see Caginalp, Porter and Smith 2001). This would exacerbate any inherent tendency for the market to bubble, as well as confounding the effect of the incentive structure with that of excess liquidity.

In a Noussair market, both the intrinsic value and the ratio of cash to stock remain constant over time, and so the new inflow that each trader receives in the baseline condition is simply 1,600 ECU plus two shares at the end of each year. In a Smith market, in which the intrinsic

13 This is only true on average because the actual value depends upon the realized dividends and holding costs.

14 In period seven of a standard fifteen-period SSW market, the corresponding ratio is on average 2.0208.

value of a share declines over time, each inflow consists of two shares plus an amount of cash that increases in each successive year.

To see why this is the case, notice firstly that one-quarter of our Smith endowment is 624 ECU and two shares. By the end of the first year, however, each share has already paid out four dividends. To bring the value of the first inflow back up to one-quarter of the initial endowment, it is thus necessary to add back the expected dividends that would have accrued on the two shares (24×4×2 = 192 ECU) had they been held since the start of the market. Thus each trader receives two shares and 816 ECU at the end of the first year, with the cash component increasing to 1,008, 1,200 and 1,392 ECU at the end of each successive year.[15]

Tournament incentive parameters

In our tournament condition, the paper value of each trader's holdings of money and shares is computed at the end of each market year. We assess the paper value of shares using the median transaction price over the previous quarter, where the median price is chosen because it is more difficult to manipulate than other measures of value such as the mean or closing price. Each trader is then ranked from one to nine on the basis of the year-on-year growth in the paper value of their portfolio.[16] The reason we evaluate returns on a year-on-year basis is to ensure that no trader is ever out of contention to attain a high rank in the current year on account of poor decisions that may have been made in previous years.

At the end of each year, we allocate new inflows on the basis of a trader's rank over the past year. The three top-ranked traders receive new money and shares amounting to double what they would have received in the corresponding baseline condition. The three middle-ranked traders receive the same new inflow as under the baseline, while the three bottom-ranked traders receive nothing. As a result, the aggregate infusion of new money and shares into the market as a whole is the same at the end of each year as in the corresponding baseline.

15 Since the extra cash simply compensates for the dividends that would have been paid had the shares been in circulation since the beginning of the market, this procedure has the property that the aggregate ratio of cash to the intrinsic value of stock is identical to that which would have prevailed in the absence of any infusion.

16 In the first market year, we assess the initial value at intrinsic value. Note however that this has no effect upon the outcome of the ranking, since all traders start out with an identical endowment.

Details of sessions

We completed our experiments between August 2009 and May 2010 in the experimental economics laboratory of an Australian research university. We over-recruited participants to each session to ensure that there would be exactly nine traders in every market. In some sessions we conducted two simultaneous but independent markets on separate sides of the lab, with the instructions explaining clearly that there would only be nine traders in each of the markets.[17] All participants were currently enrolled students of the university, and none had ever participated in any previous asset market experiment. We managed the recruitment of participants using ORSEE (Greiner 2004) and the experiment was programmed in z-Tree (Fischbacher 2007).

We conducted a total of six markets in each of the Smith baseline and Smith tournament conditions, and four markets in each of the Noussair baseline and tournament conditions. Each market yields one inexperienced observation and one experienced observation. Each session ran for approximately 2.5 hours in duration, and the average payment was AUD 46 (approximately USD 39 at the time of the experiments). Table 1 summarizes our design.

[Table 1 about here.]

RESULTS

We derive our primary results in the Smith environment. In this setting, we find that market prices deviate significantly further from intrinsic value under league-table incentives than in the baseline, and this is especially the case in experienced markets. In particular, in our Smith baseline markets we find that prices track significantly closer to intrinsic value with experience, whereas in Smith tournament markets experience has the opposite effect. Further, the effects of incentives are also observed in the Noussair environment. We find that with experience, baseline Noussair markets price at intrinsic value with near-perfect accuracy, whereas in the tournament condition there is persistent mispricing even with experience.

In support of these findings, we analyze period-wise differences in median transaction prices across the different dimensions of our design. We also report a range of standard summary measures of market performance from the literature on experimental asset markets. Before reporting our analysis, we first define these measures.

[17] See Appendix 1, which contains the full text of the instructions for the Smith tournament treatment.

Bubble measures

We follow the experimental literature in computing a range of so-called "bubble measures". Since these measures normalize for differences in parameterization, they facilitate the comparison of effects not only across the various dimensions of our design, but also against the broader literature on markets of this type. For those measures that are defined in terms of period-wise aggregates of the price, we use the median transaction price as our summary measure of the price in each period. The measures that we consider are defined below.

Amplitude is a measure of the overall peak-to-trough deviation in period-wise transaction prices from intrinsic value. As defined by Haruvy and Noussair (2006), the maximum and minimum deviations are evaluated relative to contemporaneous intrinsic value, such that:

$$Amplitude = \max_t \left[\left(P_t - f_t \right) / f_t \right] - \min_t \left[\left(P_t - f_t \right) / f_t \right]$$

where P_t is the (median) transaction price in period t and f_t is intrinsic value in period t. A large value of this measure indicates large price swings relative to intrinsic value.

Duration (Porter and Smith 1995) is the length of the longest consecutive sequence of periods over which the deviation of price from intrinsic value increases from one period to the next:

$$Duration = \max \left(m : P_t - f_t < P_{t+1} - f_{t+1} < \ldots < P_{t+m} - f_{t+m} \right)$$

Turnover is a measure of the total volume of trade over the life of a market relative to the total number of shares on issue. As originally defined by King (1991), *Turnover* is given by:

$$Turnover = \sum_{t=1}^{T} q_t \Big/ TSU$$

where T is the number of trading periods, q_t is the number of shares transacted in period t and TSU ("total stock of units") is the total number of shares on issue. Since our design involves the periodic infusion of new shares, we need to adjust the above expression to correct for the number of shares on issue in any given period. Accordingly, we define *Adjusted Turnover* as:

$$Adjusted\ Turnover = \sum_{t=1}^{T} \left(q_t / TSU_t \right)$$

where TSU_t is the total stock of units in period t. Clearly, this reduces to the standard definition of *Turnover* for the case in which the total stock of units is the same in all periods.

Average Bias (Haruvy and Noussair 2006) is a measure of the average strength and direction of period-wise deviations in price from intrinsic value:

$$Average\ Bias = \frac{1}{T}\sum_{t=1}^{T}\left(P_t - f_t\right)$$

Average Dispersion (Palan 2009) measures the average *absolute* deviation in price in each period from intrinsic value.[18] It differs from *Average Bias* in that it penalizes both positive and negative deviations, where these potentially cancel out in the expression for *Average Bias*. The *Average Dispersion* is defined as:

$$Average\ Dispersion = \frac{1}{T}\sum_{t=1}^{T}\left|P_t - f_t\right|$$

Normalized Absolute Price Deviation (King et al 1993) measures the aggregate absolute deviation of individual transaction prices from intrinsic value, normalized by the *TSU*:

$$Deviation = \sum_{t=1}^{T}\sum_{i=1}^{q_t}\left|P_{it} - f_t\right| \Big/ \left(100 \times TSU\right)$$

where P_{it} is the price of the *i*-th share transacted in period *t*. This measure combines both volume and price information into a single measure that penalizes high turnover at prices that deviate substantially from intrinsic value.[19] In our design, it is again necessary to correct for the periodic infusion of new stock. Accordingly, we define *Adjusted Deviation* as:

$$Adjusted\ Deviation = \sum_{t=1}^{T}\left\{\sum_{i=1}^{q_t}\left|P_{it} - f_t\right| \Big/ \left(100 \times TSU_t\right)\right\}$$

Once again, this clearly reduces to the standard definition of *Deviation* for the case in which the total stock of units remains the same in every period.

Finally, we introduce a new measure of the variation in earnings between traders in a market. We define the *Normalized Earnings Variation* as the standard deviation of traders' earnings in a given market (expressed in units of experimental currency) normalized by the *ex ante* expected earnings of each trader. In our design, these expected earnings are simply the sum

[18] A measure of *Total Dispersion* was introduced by Haruvy and Noussair (2006). We follow Palan (2009) in normalizing for the number of trading periods.

[19] The reason for dividing by 100 in the expression for *Deviation* is to make the results of our study, in which dividends are expressed as 0, 8, 28 or 60 experimental 'cents' comparable to earlier studies in which the dividends were expressed as 0.00, 0.08, 0.28 or 0.60 experimental 'dollars'.

of the intrinsic values of all initial endowments, plus the total infusions of cash and stock into the market, all averaged over the total number of traders in the market.

In our design there are two distinct sources of earnings variation. Firstly, under both incentive conditions, some traders may execute more profitable transactions at the expense of others. Secondly, under our league-table incentives, the end-of-year bonuses are also allocated unequally. If positions in the end-of-year rankings are uncorrelated from one year to the next, then this will not on average inflate the variation in earnings. On the other hand, if relative position is persistent over time then this will lead to larger values of the measure. We use this measure to examine both how the variability in earnings evolves with experience within a given incentive condition, as well as how it compares across the two incentive conditions.

Results for Smith markets

Figure 1 plots the time paths of median transaction prices in each trading period for each of our six Smith baseline markets. In this Figure, the left-hand panel depicts the inexperienced market repetition while the right-hand panel represents the experienced repetition. The lower stepped line represents the time path of intrinsic value, while the upper stepped line represents the *maximum* holding value of a share, in the event that it pays the maximum possible dividend of 60 in each of the remaining periods. This maximum value is of interest since transactions at prices in excess of it can only be motivated either by speculation or irrationality (Lei et al 2001). Figure 2 shows the corresponding price paths for our six Smith tournament markets. This has been drawn to a different scale to Figure 1 in order to accommodate the very high prices observed in two of the markets. Table 2 reports the bubble measures for each of our Smith markets, along with the averages of these measures for each treatment-experience combination.

[Figures 1 and 2 and Table 2 about here.]

We organize our findings for the Smith environment into four results. We first show that, relative to the baseline, there is a small effect of league-table incentives in inexperienced markets, and a much larger one in experienced markets. We then establish that this occurs both because prices track closer to intrinsic value with experience under the baseline, and because they deviate further from intrinsic value with experience under the tournament.

Incentive effects in Smith markets

RESULT 1: In inexperienced Smith markets, the *Amplitude* and *Duration* are significantly greater under league-table incentives. This occurs primarily because these markets typically do not crash back to intrinsic value in the final periods.

Figures 1 and 2 show that prices typically exceed intrinsic value in inexperienced Smith markets under both baseline and tournament incentives. As has been observed in previous studies of markets of this kind, prices in baseline markets typically crash back toward intrinsic value as shares approach the end of their life. However this is not the case for the tournament markets. Indeed, in five of these six markets, prices remain above the *maximum* holding value over the final three trading periods.

The effect of incentives in inexperienced Smith markets can be seen more clearly in the left-hand panel of Figure 3. Here, the dashed line depicts the average price path for the six baseline markets, while the solid line shows the average for the six tournament markets. While prices are consistently higher in tournament markets, the two series appear to diverge from around period twelve onward. To evaluate the significance of these differences, we compute one-sided p-values for the Fisher-Pitman permutation test for independent samples, using the period median transaction prices in each of the markets as independent observations.[20] The full test results are reported in the first panel of Appendix 2. In Figure 3, the background shading is used to illustrate the significance level of the difference in prices between incentive conditions according to these tests. It shows that prices in the tournament condition are higher with at least marginal significance from period thirteen onward.

[Figure 3 about here.]

In the left-hand panel of Table 3, we report one-sided p-values of the independent-samples permutation test for each of the bubble measures in our inexperienced Smith markets. The one-sided null hypothesis is that the respective measure is no larger under the tournament. Contrary to this, we find that the tournament condition is associated with significantly larger *Amplitude* and *Duration*. On the other hand, the lack of any significant difference in *Bias*,

[20] This is a more powerful, but computationally-demanding, alternative to the Wilcoxon rank-sum test; see Kaiser (2007) or Siegel and Castellan (1988) for details. The one-sided null hypothesis is that the median transaction price in period t is no greater under the tournament. Since we perform the test separately for each trading period, each market contributes only a single independent observation to each test.

Dispersion and *Deviation* indicates that, over the full sixteen-period life of the inexperienced markets, prices are not significantly more distorted under the tournament. Similarly, the lack of any significant difference in *Earnings Variation* suggests that there is not a great deal of year-to-year persistence in relative performance in the inexperienced tournament.

[Table 3 about here.]

RESULT 2: In experienced Smith markets, prices are significantly more severely distorted under league-table incentives. This is the case in all but the very first periods, and is reflected in all measures except *Turnover*.

The right-hand panel of Figure 2 shows that, even in the experienced repetition, pronounced price bubbles occur in all six tournament markets, and four of these do not end in a crash. In two of the markets, prices rise above the maximum holding value from as early as period eight, and remain at those levels for the remainder of the market. Short of irrationality, prices at such extreme levels can only be explained by speculation.

The right-hand panel of Figure 3 shows that from period three onward, prices in experienced tournament markets are always significantly higher than in experienced baseline markets, at a significance level of at least 5% in a one-sided independent-samples permutation test.[21] The results of the corresponding tests for our summary bubble measures are reported in the right-hand panel of Table 3. For four of these measures, a significance level of 1% is attained, notwithstanding the fact that there are only six observations in each incentive condition.

The bubble measures thus confirm that prices in experienced tournament markets are significantly further from intrinsic value compared to the experienced baseline. Moreover, in contrast to the inexperienced repetition, the tournament is associated with highly significantly greater variation in earnings. The only measure for which we do not obtain at least a marginally significant effect is *Turnover*: on average, experienced tournament markets are associated with slightly lower *Turnover* but this difference is not statistically significant.[22]

In summary, we obtain strong evidence that price bubbles are very significantly inflated under league-table incentives in experienced Smith markets. This effect is not observed to nearly the same extent in inexperienced markets. We next show that these effects are

21 The full test results are reported in the second panel of Appendix 2.

22 The one-sided null hypothesis that *Turnover* is no less under tournament is also not rejected, with $p = 0.166$.

observed for two reasons. Firstly, and consistent with previous research on Smith markets, prices track intrinsic value more closely with experience in the baseline. Secondly, in markets with league-table incentives, prices in fact become more distorted with experience.

Experience effects in Smith markets

RESULT 3: In Smith markets with baseline incentives, the effect of experience is to cause prices to track significantly closer to intrinsic value through the middle periods of the market, as reflected in the *Amplitude*, *Bias*, *Dispersion* and *Deviation*.

The left-hand panel of Figure 4 compares the average price paths in the inexperienced (dashed) and experienced (solid) repetitions of the Smith baseline markets. Whereas the inexperienced markets tend to bubble and crash through the middle periods, the experienced markets on average track only slightly above intrinsic value.

[Figure 4 about here.]

To formally evaluate the significance of these differences, we compute one-sided *p*-values for the Fisher-Pitman permutation test for paired replicates. This is the single-sample analogue to the test used in the previous subsection, and provides a more powerful alternative to the Wilcoxon signed-ranks test. The full test results are reported in the third panel in Appendix 2, and in Figure 4 we use the background shading to illustrate the significance levels of the differences according to these tests. The left-hand panel of Table 4 reports the corresponding tests for our summary bubble measures. In each test, the one-sided null hypothesis is that prices are no closer to intrinsic value in the experienced repetition.

[Table 4 about here.]

Contrary to this hypothesis, Figure 4 shows that the experienced baseline markets track closer to intrinsic value with at least marginal significance in periods seven through to thirteen. Since prices in Smith markets often start out somewhat below intrinsic value (as can also be seen in Figure 4) and then crash in the final periods, these middle periods are the ones characteristically associated with price bubbles.

Thus, consistent with a robust finding of previous research, we find that price bubbles are significantly diminished with experience in Smith markets under baseline incentives. This is confirmed in Table 4 with respect to the *Amplitude*, as well as the three measures of the accuracy with which prices track intrinsic value, namely *Bias*, *Dispersion* and *Deviation*.

RESULT 4: In Smith markets with league-table incentives, prices deviate further from intrinsic value with experience, as measured by the *Amplitude*, *Bias* and *Dispersion*.

The right-hand panel of Figure 4 compares the average price paths in the inexperienced and experienced repetitions of the Smith tournament markets. In both repetitions, prices are generally above intrinsic value, but in the experienced repetition they are further away in all sixteen trading periods. The background shading represents the level of significance of these differences in the permutation test for paired replicates, this time under the one-sided null hypothesis that prices are no further from intrinsic value in the experienced repetition.[23] The corresponding tests for our bubble measures are reported in the right-hand panel of Table 4.

Figure 4 indicates that the price differences are at least marginally significant between periods two and ten – indicating that a price bubble "takes off" earlier in the experienced tournament – and again in periods fourteen and fifteen. Similarly, Table 4 shows that in Smith tournament markets, the experienced repetition is characterized by marginally significant increases in *Amplitude*, *Bias, Dispersion* and *Earnings Variation*.

Thus in the Smith environment, the distortionary effect of league-table incentives is powerful enough that not only does it overturn the usual tendency for price bubbles to diminish with experience, if anything it makes them even worse. We believe we are the first in the literature to observe an effect of this nature without changing market parameters between repetitions.

Results for Noussair markets

Figures 5 and 6 plot the time paths of median transaction prices in each of the Noussair baseline and tournament markets respectively. Table 5 reports bubble measures for each market, along with averages for each treatment-experience combination. Because we collected only four market observations in each of the Noussair baseline and tournament conditions, we limit our analysis to a between-groups comparison of incentive effects – we lack sufficient observations to obtain anything more than marginal significance in within-group experience comparisons. Nonetheless, our data point strongly to the following result:

[23] The full test results are in the fourth panel of Appendix 2.

RESULT 5: In Noussair markets, prices are significantly further from intrinsic value under league-table incentives, across both market repetitions. This is reflected in all bubble measures with the exception of *Duration*. In particular, prices in experienced baseline markets settle almost precisely at intrinsic value. By contrast, experienced tournament markets remain persistently above intrinsic value.

[Figures 5 and 6 and Table 5 about here.]

Figure 5 shows that after some initial volatility, prices in each of the Noussair baseline markets settle at intrinsic value by around the tenth period of the first repetition, and remain there throughout the entire second repetition. In contrast, Figure 6 shows that prices take longer to settle in the Noussair tournament markets, and only one of the four markets ever settles at intrinsic value. Each of the tournament markets nonetheless appears to reach an "equilibrium" price by around period fourteen of the first repetition, and remains there throughout the entire second repetition. However in three of the markets this "equilibrium" occurs at a price somewhat above intrinsic value.

Figure 7 summarizes the average price paths for the Noussair baseline and tournament conditions. Once again, the background shading represents the significance level of the difference between the two incentive conditions in a given period, in an independent-samples permutation test under the one-sided null hypothesis that prices are no higher under the tournament.[24] It shows that the price differences are at least marginally significant in almost every trading period across both market repetitions.

[Figure 7 and Table 6 about here.]

Table 6 reports the analysis of our summary bubble measures. In both the inexperienced and experienced repetitions, the *Turnover*, *Bias*, *Dispersion*, *Deviation* and *Earnings Variation* are all greater with at least marginal significance in the tournament condition. In addition, there is also a marginally significant effect for *Amplitude* in inexperienced markets.

Although the magnitude of the price differences between the two incentive conditions is clearly smaller than in the Smith environment – amounting to around five percent of intrinsic value in the experienced repetition – it appears that league-table incentives can again induce a

[24] The full test results are in Appendix 3.

market to “defy gravity”. This occurs even when the participants are experienced, and in a setting in which experienced baseline markets price correctly.

CONCLUSION

In experimental asset markets, we find that price bubbles can be very significantly inflated when traders compete to attract new fund inflows, where the size of these flows is determined by their relative performance as measured by short-term paper returns. A recent body of literature argues that this describes the incentives facing professional fund managers. We find that the severity of the effect of league-table incentives depends upon the extent to which traders face a tension between the pursuit of market and intrinsic values.

We observe our most pronounced effects in the Smith market environment. This design is sometimes criticized on the grounds that its declining-value feature is not a fair representation of real-world financial markets (Kirchler, Huber and Stöckl 2009). On the contrary, we consider the Smith environment to be a reasonable model of market conditions during a period of market turbulence – that is, when investors are reassessing expected future stock earnings in a downward direction – pointing, in the limit, to the possibility of a firm’s bankruptcy. In our Smith baseline condition we confirm that, with experience, market participants learn to incorporate such expectations into the price. However, such judgments appear to be overruled in the presence of league-table incentives, such that market prices are able to “defy gravity”, often right through to the bitter end. We consider these to be our primary results.

By contrast, we interpret the Noussair market environment as modeling a situation in which market fundamentals are stable, and in which there exists a widely-accepted benchmark of value. This has previously been shown to be a setting in which price bubbles and crashes are less likely to occur. By extending our design to also encompass this environment, we seek to examine whether league-table incentives may be powerful enough to have a discernable effect even in a setting in which the intrinsic value ought to be transparently clear. We find that this is indeed also the case.

Our findings are significant because of the prevalence of league-table style incentives (whether explicit or implicit) throughout many sectors of the economy, because of the influence that fund managers carry in financial markets, and because of the importance of managed investments to the savings and retirement decisions of retail investors.

Notwithstanding the difficulty posed by the unobservability of intrinsic value in real world markets, our results also challenge regulators to develop more reliable means to inform investors' fund allocation decisions – as opposed to merely mandating the reporting and publication of returns information derived from potentially misleading accounting measures.

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TABLE 1: SUMMARY OF DESIGN

	Smith Environment	**Noussair Environment**
Number of baseline markets	6	4
Number of tournament markets	6	4
Number of repetitions per market	2	2
Traders per market	9	9
Number of trading periods	16	16
Dividend realizations	0, 8, 28, 60	−24, −16, 4, 36
Expected dividend per period	24	0
Redemption value per share	0	400
Intrinsic value in period 1	384	400
Initial endowment	2,496 ECU / 8 shares	6,400 ECU / 8 shares
Intrinsic value of endowment	5,568	9,600
Initial cash to stock ratio	0.8125	2
Baseline inflow period 4	816 ECU / 2 shares	1,600 ECU / 2 shares
Baseline inflow period 8	1,008 ECU / 2 shares	1,600 ECU / 2 shares
Baseline inflow period 12	1,200 ECU / 2 shares	1,600 ECU / 2 shares
Baseline inflow period 16	1,392 ECU / 2 shares	1,600 ECU / 2 shares
Treatment inflow top 3	Double baseline	Double baseline
Treatment inflow middle 3	Same as baseline	Same as baseline
Treatment inflow bottom 3	Nil	Nil
Exchange rate	500 ECU / AUD	800 ECU / AUD
Average earnings per trader	AUD 45.6	AUD 47.4

TABLE 2: BUBBLE MEASURES IN SMITH MARKETS

	Amplitude	*Duration*	*Adjusted Turnover*	*Average Bias*	*Average Dispersion*	*Adjusted Deviation*	*Earnings Variation*
Baseline Inexperienced							
Market 101	1.656	9	2.977	32.750	69.688	2.119	0.224
Market 102	3.501	12	5.199	34.594	110.656	5.359	0.365
Market 103	2.458	11	5.479	91.563	96.313	6.666	0.434
Market 104	8.979	3	6.103	117.781	153.969	11.371	0.699
Market 105	0.573	1	5.119	2.969	12.156	0.704	0.088
Market 106	0.326	4	2.723	−18.094	19.219	0.831	0.119
Average	**2.916**	**6.667**	**4.600**	**43.594**	**77.000**	**4.508**	**0.321**
Tournament Inexperienced							
Market 111	9.063	15	5.148	25.125	98.000	5.381	0.390
Market 112	4.201	10	2.648	48.031	48.031	1.389	0.316
Market 113	14.411	15	2.414	160.063	160.063	4.011	0.439
Market 114	7.372	9	5.304	57.219	58.719	2.176	0.430
Market 115	4.570	8	2.760	66.313	80.688	2.436	0.451
Market 116	3.047	11	5.149	139.656	145.156	7.227	0.818
Average	**7.111**	**11.333**	**3.904**	**82.734**	**98.443**	**3.770**	**0.474**
Baseline Experienced							
Market 101	0.333	6	2.658	−40.906	40.906	1.193	0.129
Market 102	0.923	6	2.994	17.438	41.188	1.406	0.186
Market 103	1.545	10	6.130	85.375	85.875	5.625	0.436
Market 104	8.802	14	5.894	72.219	97.406	5.864	0.276
Market 105	0.550	1	4.132	−3.406	3.656	0.247	0.158
Market 106	0.458	4	3.107	−48.781	48.781	1.630	0.124
Average	**2.102**	**6.833**	**4.152**	**13.656**	**52.969**	**2.661**	**0.218**
Tournament Experienced							
Market 111	47.241	15	5.054	423.094	448.656	20.054	0.793
Market 112	13.685	14	3.232	172.750	177.625	5.914	0.661
Market 113	10.828	12	3.286	307.625	307.625	8.994	0.993
Market 114	11.595	8	2.739	87.844	87.844	2.048	0.521
Market 115	9.339	11	2.924	76.031	81.531	1.718	0.357
Market 116	1.659	9	3.588	99.156	102.656	4.295	0.758
Average	**15.724**	**11.500**	**3.471**	**194.417**	**200.990**	**7.171**	**0.680**

TABLE 3: INCENTIVE EFFECTS IN SMITH MARKETS

	Inexperienced			Experienced		
	Baseline (Average)	Tournament (Average)	Permutation test (one-sided *p*-value)	Baseline (Average)	Tournament (Average)	Permutation test (one-sided *p*-value)
Amplitude	2.916	7.111	0.037**	2.102	15.724	0.002***
Duration	6.667	11.333	0.040**	6.833	11.500	0.035**
Adjusted Turnover	4.600	3.904	0.859	4.152	3.471	0.835
Average Bias	43.594	82.734	0.114	13.656	194.417	0.002***
Average Dispersion	77.000	98.443	0.232	52.969	200.990	0.005***
Adjusted Deviation	4.508	3.770	0.637	2.661	7.171	0.066*
Earnings Variation	0.321	0.474	0.117	0.218	0.680	0.002***

TABLE 4: EXPERIENCE EFFECTS IN SMITH MARKETS

	Baseline			Tournament		
	Inexperienced (Average)	Experienced (Average)	Permutation test (one-sided *p*-value)	Inexperienced (Average)	Experienced (Average)	Permutation test (one-sided *p*-value)
Amplitude	2.916	2.102	0.047**	7.111	15.724	0.094*
Duration	6.667	6.833	0.563	11.333	11.500	0.500
Adjusted Turnover	4.600	4.152	0.203	3.904	3.471	0.250
Average Bias	43.594	13.656	0.016**	82.734	194.417	0.078*
Average Dispersion	77.000	52.969	0.094*	98.443	200.990	0.078*
Adjusted Deviation	4.508	2.661	0.047**	3.770	7.171	0.125
Earnings Variation	0.321	0.218	0.125	0.474	0.680	0.094*

TABLE 5: BUBBLE MEASURES IN NOUSSAIR MARKETS

	Amplitude	*Duration*	*Adjusted Turnover*	*Average Bias*	*Average Dispersion*	*Adjusted Deviation*	*Earnings Variation*
				Baseline Inexperienced			
Market 201	0.298	2	6.056	−13.156	19.406	3.988	0.332
Market 202	0.100	1	4.233	0.219	4.594	1.211	0.080
Market 203	0.128	2	3.826	−5.000	5.250	0.861	0.078
Market 204	0.138	2	3.045	−8.625	9.750	1.864	0.164
Average	**0.166**	**1.750**	**4.290**	**−6.641**	**9.750**	**1.981**	**0.164**
				Tournament Inexperienced			
Market 211	0.270	1	4.722	7.000	8.000	2.397	0.352
Market 212	0.311	1	5.791	96.031	96.031	6.557	0.486
Market 213	0.596	1	4.806	8.406	31.031	1.932	0.266
Market 214	0.138	3	12.552	26.875	26.875	4.361	0.578
Average	**0.329**	**1.500**	**6.968**	**34.578**	**40.484**	**3.811**	**0.421**
				Baseline Experienced			
Market 201	0.005	1	6.575	0.656	0.656	0.169	0.037
Market 202	0.015	1	2.796	−0.469	0.781	0.021	0.053
Market 203	0.005	1	3.320	0.063	0.438	0.350	0.098
Market 204	0.030	1	2.056	−1.375	1.750	0.044	0.054
Average	**0.014**	**1.000**	**3.687**	**−0.281**	**0.906**	**0.146**	**0.060**
				Tournament Experienced			
Market 211	0.005	3	5.219	0.344	0.594	0.082	0.293
Market 212	0.010	1	4.176	38.969	38.969	1.642	0.184
Market 213	0.023	1	4.823	17.063	17.063	0.850	0.202
Market 214	0.065	2	12.461	19.063	19.063	3.226	0.302
Average	**0.026**	**1.750**	**6.670**	**18.859**	**18.922**	**1.450**	**0.245**

TABLE 6: INCENTIVE EFFECTS IN NOUSSAIR MARKETS

	Inexperienced			Experienced		
	Baseline (Average)	**Tournament (Average)**	**Permutation test (one-sided *p*-value)**	**Baseline (Average)**	**Tournament (Average)**	**Permutation test (one-sided *p*-value)**
Amplitude	0.166	0.329	0.086*	0.014	0.026	0.314
Duration	1.750	1.500	0.814	1.000	1.750	0.214
Adjusted Turnover	4.290	6.968	0.086*	3.687	6.670	0.100*
Average Bias	−6.641	34.578	0.014**	−0.281	18.859	0.029**
Average Dispersion	9.750	40.484	0.043**	0.906	18.922	0.057*
Adjusted Deviation	1.981	3.811	0.086*	0.146	1.450	0.043**
Earnings Variation	0.164	0.421	0.029**	0.060	0.245	0.014**

FIGURE 1: PRICE PATHS IN SMITH BASELINE MARKETS

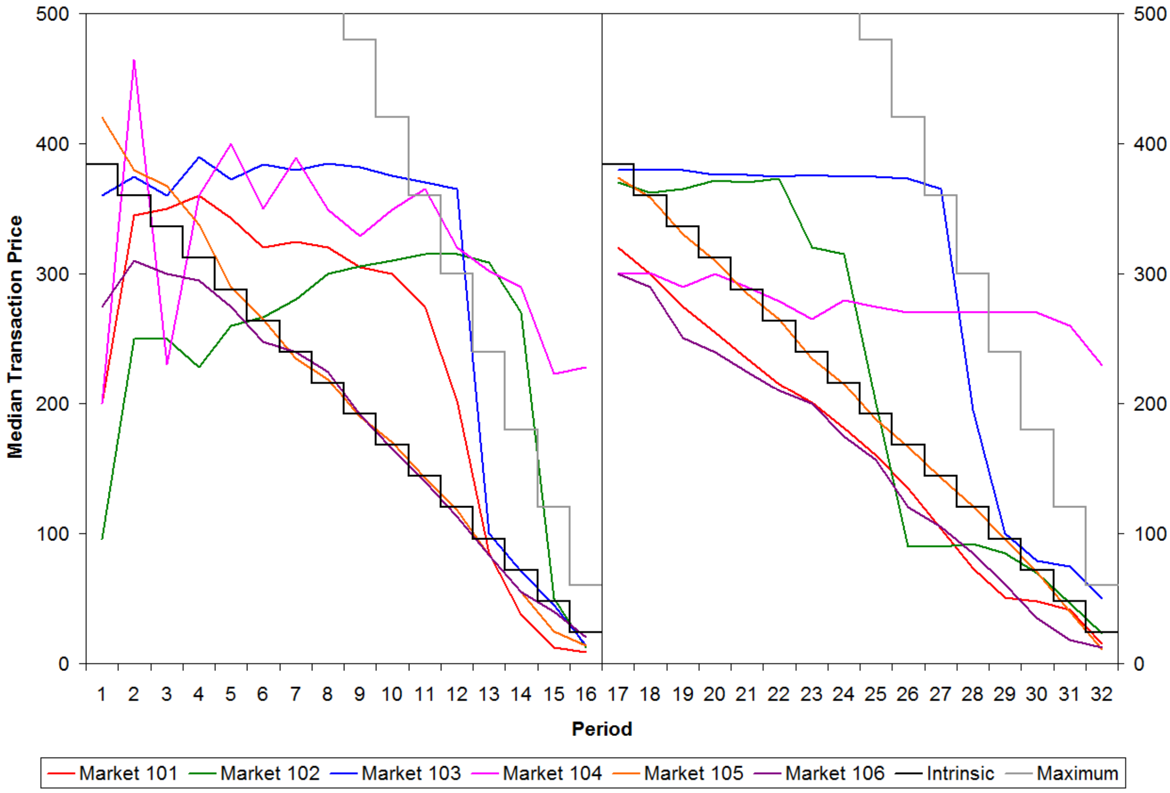


FIGURE 2: PRICE PATHS IN SMITH TOURNAMENT MARKETS

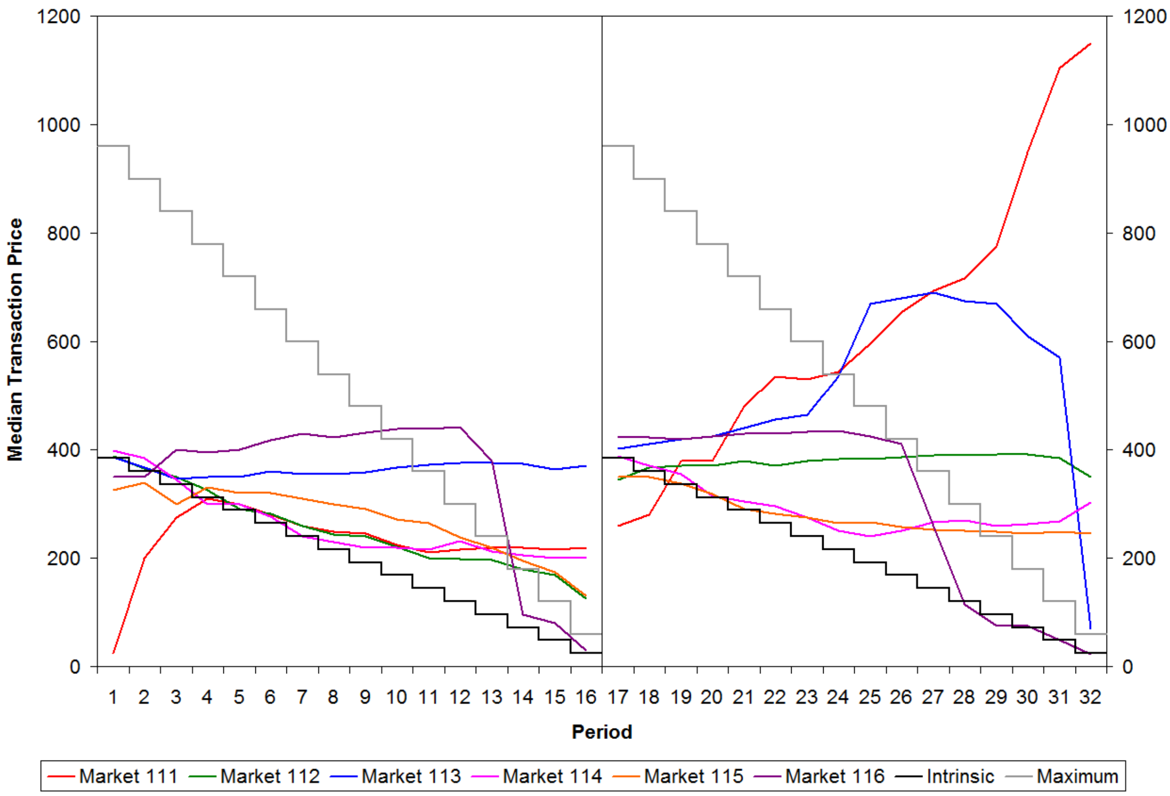


FIGURE 3: INCENTIVE EFFECTS IN SMITH MARKETS

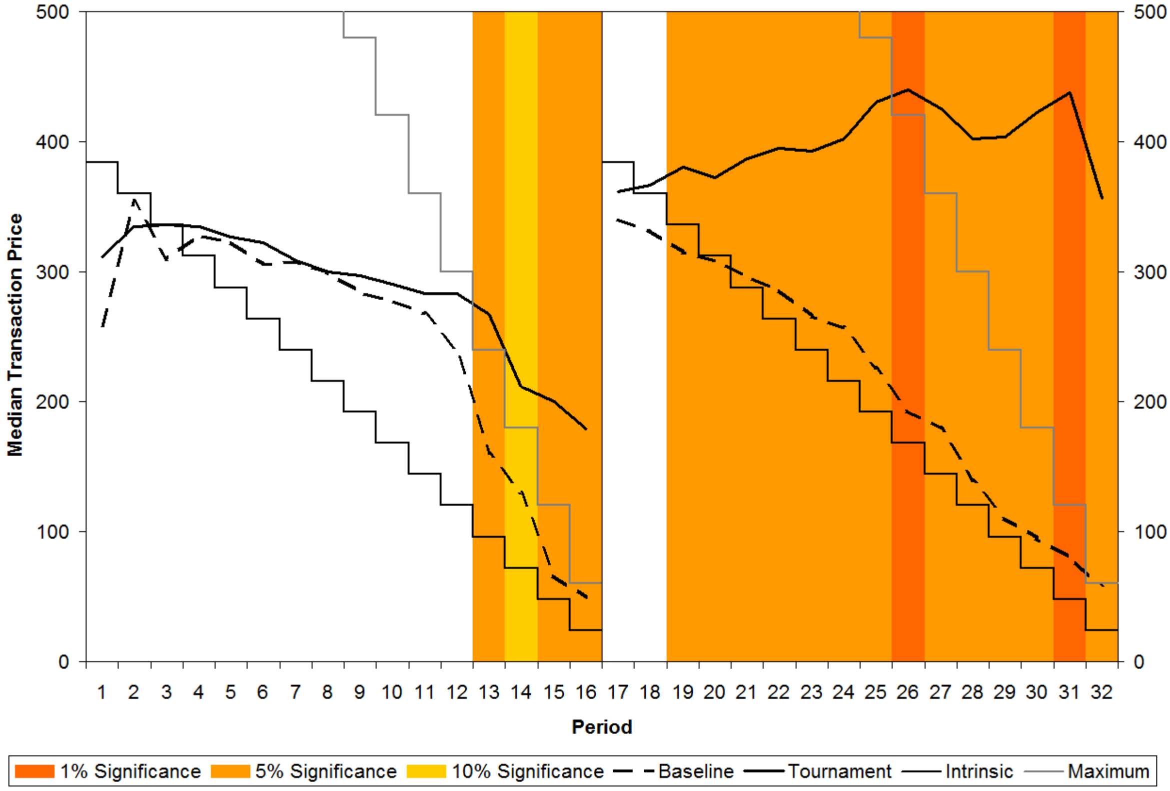


FIGURE 4: EXPERIENCE EFFECTS IN SMITH MARKETS

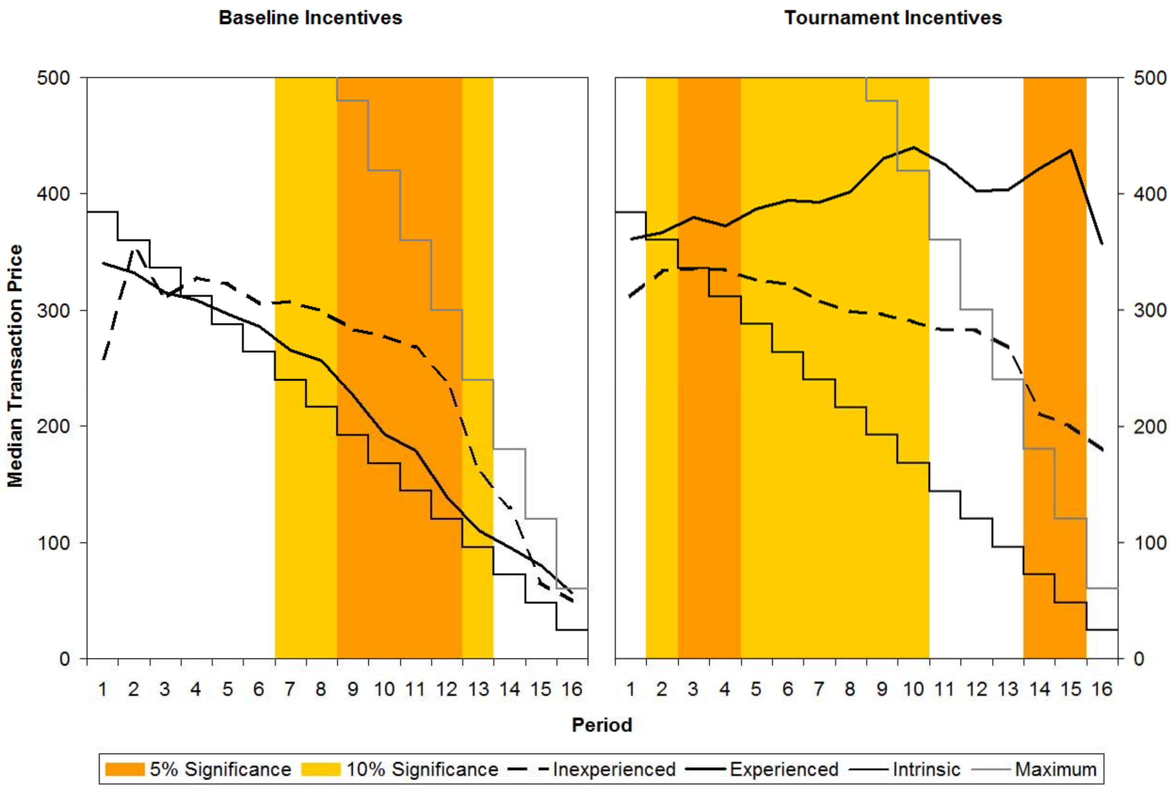


FIGURE 5: PRICE PATHS IN NOUSSAIR BASELINE MARKETS

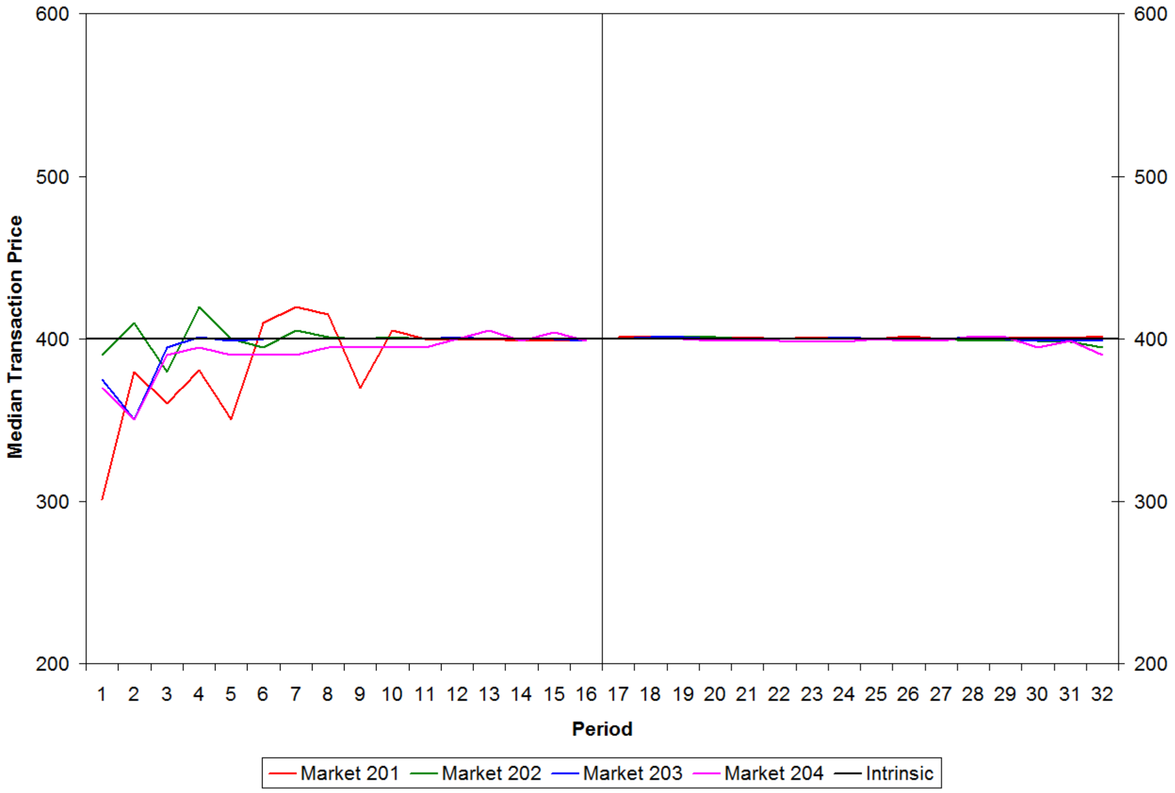


FIGURE 6: PRICE PATHS IN NOUSSAIR TOURNAMENT MARKETS

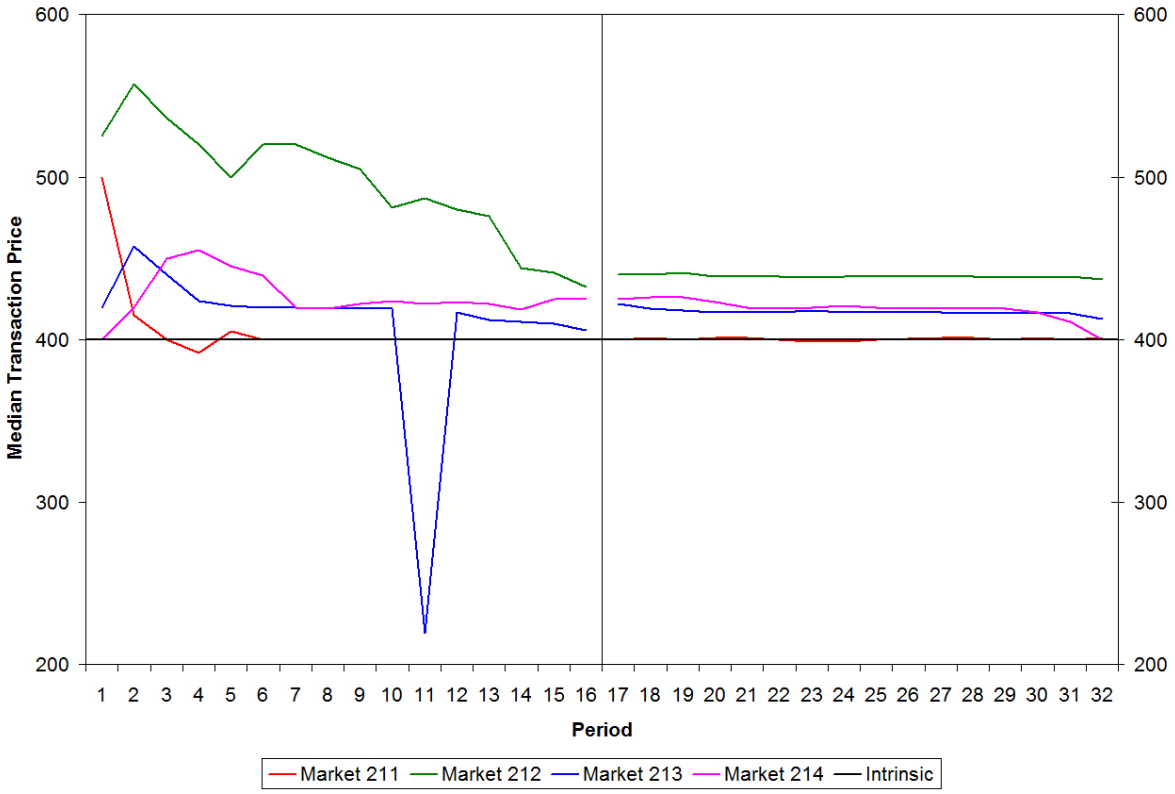
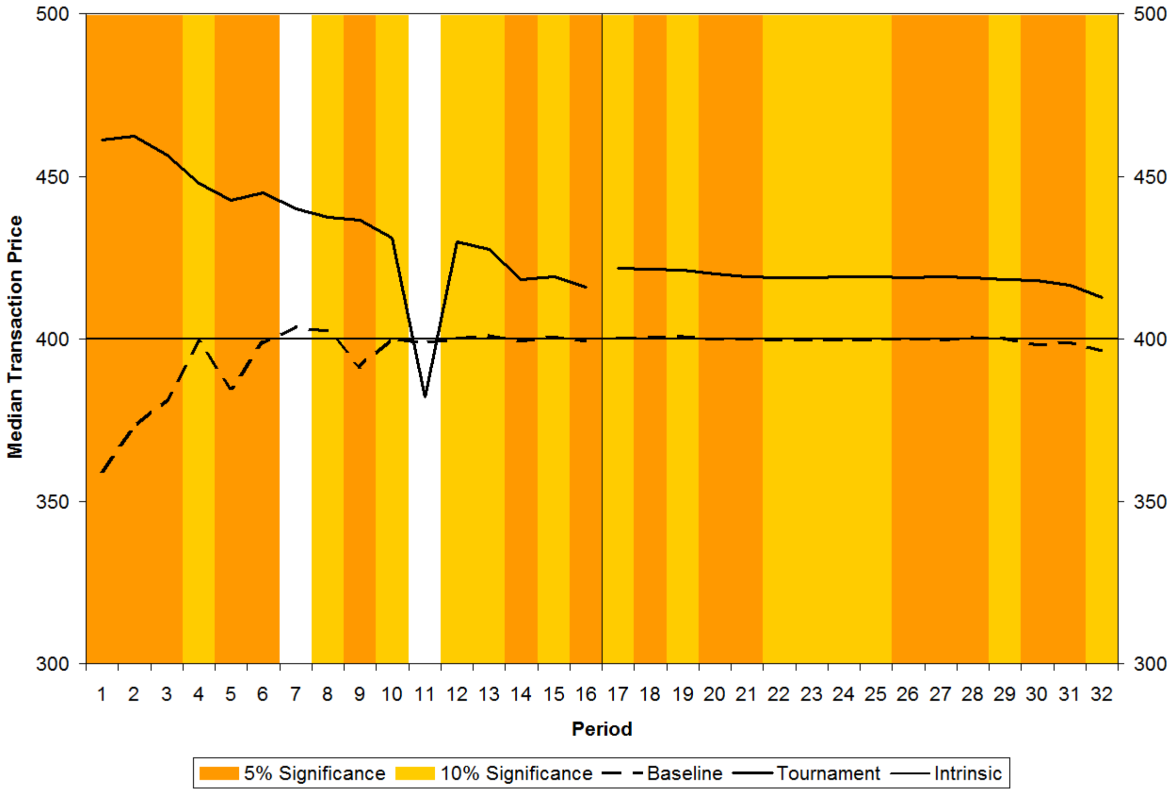


FIGURE 7: INCENTIVE EFFECTS IN NOUSSAIR MARKETS



APPENDICES – NOT FOR PUBLICATION

APPENDIX 1: INSTRUCTIONS FOR THE SMITH INCENTIVE TREATMENT ‡

General Instructions

This is an experiment in the economics of decision making in a market. The instructions are simple and if you follow them carefully and make good decisions you may earn a considerable amount of money which will be paid to you in cash at the end of the experiment.

It is imperative that you do not communicate with any other participant while the experiment is in progress. If you communicate with another participant, the data will lose its scientific value and we will not be able to pay any of the participants. It is therefore in your common interest to follow this strict ban on communication. If you have any questions please raise your hand, and an experimenter will come to you and answer your questions in private.

The main part of the experiment will consist of two rounds of trading periods in which you have the opportunity to buy and sell shares in a market. The currency used in this market is "Experimental Currency Units" (ECU). All trading will be in terms of ECU. The cash payment to you at the end of the experiment will be in Australian Dollars. The conversion rate is **500 ECU to 1 Australian Dollar**.

How to use the Computerised Market

In the top right hand corner of the screen you see how much time is left in the current trading period. The items you can buy and sell in the market are called shares. In the centre of your screen you see the number of shares you currently have and the amount of money you have available to buy shares.

You can use the trading screen to participate in the market in one of four ways.

‡ Horizontal rules denote the positions of the page breaks in the original instructions. Instructions for the remaining treatments are available upon request.

Making an offer to sell a share, by entering the price at which you would like to sell

To offer to sell a share, enter the price at which you would like to sell in the box labelled "Enter offer to sell" on the left of the screen, then click on the button "Submit offer to sell".

The second column from left will show a list of offers to sell, each submitted by a different participant. Your own offer will appear in blue. Submitting a new offer will replace your previous one.

Making an offer to buy a share, by entering the price at which you would like to buy

To offer to buy a share, enter the price at which you would like to buy in the box labelled "Enter offer to buy" on the right of the screen, then click on the button "Submit offer to buy".

The second column from right will show a list of offers to buy, each submitted by a different participant. Your own offer will appear in blue. Submitting a new offer will replace your previous one.

Buying a share, by accepting an offer to sell

You can select an offer to sell in the second column from left by clicking on it. If you click the "Buy" button at the bottom of this column, you will buy one share at the selected offer-to-sell price.

Selling a Share, by accepting an offer to buy

You can select an offer to buy in the second column from right by clicking on it. If you click the "Sell" button at the bottom of this column, you will sell one share at the selected offer-to-buy price.

Transaction prices

When you buy a share your money decreases by the price of the purchase. When you sell a share your money increases by the price of the sale. In the middle column, labelled "Transaction prices", you can see a list of the prices at which shares have been bought and sold in the current trading period.

Instructions for the Experiment

Each market will have nine participants in it. *Even though there may be more than nine participants in the room today, you will always participate in a market of nine, consisting of yourself and eight others.*

The experiment consists of two rounds and you will be paid your earnings from both rounds. At the start of each round, every participant will have a starting balance of **2,496 ECU and 8 shares**.

Each round consists of 16 trading periods. In each period the market will open for three minutes during which you can buy and sell shares in exchange for ECU.

Every share you buy or sell will change your holdings of money and shares. Your holdings will carry over from one trading period to the next within the current round. At the start of the second round, your holdings will be reset to the starting values explained above.

Each trading period represents one market quarter, and thus every four periods represents one market year. Since each round runs for 16 periods, this represents four market years.

Dividends

Shares are assets with a life of 16 periods. Each share will pay dividends to its current owner at the end of each trading period. This dividend will be randomly determined by the computer, and will be the same for all shares. In particular, each share that you own at the end of a period:

- pays a dividend of 0 ECU with probability 1/4;
- pays a dividend of 8 ECU with probability 1/4;

- pays a dividend of 28 ECU with probability 1/4; and
- pays a dividend of 60 ECU with probability 1/4.

Since each of these outcomes is equally likely, the average dividend is 24 ECU in every period. After the final dividend has been paid, all shares will expire and there will be no further earnings possible from them.

Rank and portfolio value

Your rank out of nine participants in your market will be calculated at the end of every market year (four periods). This is based on your percentage return over the past year. A rank of 1 indicates the highest return over the past year. A rank of 2 indicates the second highest return, and so on. Note that your rank is based only upon your return over the last year, and not in any previous years.

The return used to generate your rank will be calculated as follows:

Return = (Value of Portfolio at end of year) / (Value of Portfolio at start of year)

The value of your portfolio is calculated as your cash holdings plus the value of your share holdings valued at the median traded share price over the last period.

Inflows of new money and shares

After every four periods you will receive an inflow of new money and shares. This will depend upon your rank. At the end of period 4, the new inflow will consist of:

1,632 ECU and 4 Shares	if your rank is between 1 and 3
816 ECU and 2 Shares	if your rank is between 4 and 6
0 ECU and 0 Shares	if your rank is between 7 and 9

At the end of period 8, it will consist of:

2,016 ECU and 4 Shares	if your rank is between 1 and 3
1,008 ECU and 2 Shares	if your rank is between 4 and 6
0 ECU and 0 Shares	if your rank is between 7 and 9

At the end of period 12, you will receive:

2,400 ECU and 4 Shares	if your rank is between 1 and 3
1,200 ECU and 2 Shares	if your rank is between 4 and 6
0 ECU and 0 Shares	if your rank is between 7 and 9

At the end of period 16, you will receive:

2,784 ECU and 4 Shares	if your rank is between 1 and 3
1,392 ECU and 2 Shares	if your rank is between 4 and 6
0 ECU and 0 Shares	if your rank is between 7 and 9

The new money and shares are added to your balance after the dividends have accrued for the period just completed. That is, you will not receive any dividends on the new shares until the end of the next period.

Summary screen

At the end of each trading period you will see a summary screen. This will provide information about your closing balance of money and shares, as well as the dividend for the period, and the effect of any new inflow of money and shares on your holdings where applicable.

Your earnings

You will be paid for your decisions in both rounds. Your earnings in each round are determined by the money you have at the end of the 16th period – after the final dividend, and after the final inflow of new money and shares. This amount is:

The money you had at the beginning of period one

+ Money you received from sales of shares − Money you spent on purchases of shares

+ Dividends you received + Money you received in new inflows.

At the end of the experiment, this amount will be converted into Australian dollars at the rate specified on page 1 of the instructions.

Average holding value table

You can use your AVERAGE HOLDING VALUE TABLE to help you make decisions.

The first column indicates the Ending Period of the current round. The second column indicates the Current Period for which the average holding value is being calculated. The third column gives the Number of Holding Periods from the Current Period until the Ending Period. The fourth column gives the Average Dividend per Period for each share that you hold. The fifth column gives the Average Holding Value per Share that you hold from now until the end of the current round.

That is, for each share that you hold for the remainder of the current round, you will earn on average the amount listed in column five.

AVERAGE HOLDING VALUE TABLE

Ending Period	Current Period	Number of Holding Periods	×	Average Dividend per Period	=	Average Holding Value per Share
16	1	16		24		384
16	2	15		24		360
16	3	14		24		336
16	4	13		24		312
16	5	12		24		288
16	6	11		24		264
16	7	10		24		240
16	8	9		24		216
16	9	8		24		192
16	10	7		24		168
16	11	6		24		144
16	12	5		24		120
16	13	4		24		96
16	14	3		24		72
16	15	2		24		48
16	16	1		24		24

APPENDIX 2: PERIOD-WISE TESTS OF MEDIAN TRANSACTION PRICE DIFFERENCES IN SMITH MARKETS

Incentive Effects in Inexperienced Smith Markets																
Period	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Baseline (Treatment average)	258.4	354.1	309.7	328.4	323.4	305.5	308.3	299.7	283.8	278.3	267.9	238.8	160.3	129.8	65.8	49.3
Tournament (Treatment average)	311.9	334.5	336.1	335.0	326.7	322.8	308.8	299.7	297.4	290.4	283.3	283.1	267.5	211.3	200.3	179.0
Permutation test (one-sided *p*-value)	0.2424	0.6807	0.1948	0.4210	0.4524	0.2976	0.4968	0.5022	0.3896	0.4091	0.3918	0.2294	0.0422	0.0996	0.0141	0.0227
Incentive Effects in Experienced Smith Markets																
Period	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Baseline (Treatment average)	340.7	331.9	315.3	308.8	296.8	286.2	266.1	256.9	225.8	192.5	179.4	139.3	110.5	95.3	80.2	56.9
Tournament (Treatment average)	361.4	366.7	380.3	372.3	387.1	394.8	392.8	401.9	430.1	439.7	425.3	402.5	403.3	422.2	437.7	356.8
Permutation test (one-sided *p*-value)	0.2413	0.1104	0.0184	0.0271	0.0292	0.0314	0.0173	0.0238	0.0130	0.0097	0.0119	0.0108	0.0152	0.0119	0.0097	0.0119
Experience Effects in Smith Baseline Markets																
Period	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Inexperienced (Treatment average)	258.4	354.1	309.7	328.4	323.4	305.5	308.3	299.7	283.8	278.3	267.9	238.8	160.3	129.8	65.8	49.3
Experienced (Treatment average)	340.7	331.9	315.3	308.8	296.8	286.2	266.1	256.9	225.8	192.5	179.4	139.3	110.5	95.3	80.2	56.9
Permutation test (one-sided *p*-value)	0.9375	0.2813	0.5938	0.2969	0.2344	0.2500	0.0938	0.0781	0.0156	0.0156	0.0313	0.0313	0.0625	0.2188	0.9219	0.8594
Experience Effects in Smith Tournament Markets																
Period	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Inexperienced (Treatment average)	311.9	334.5	336.1	335.0	326.7	322.8	308.8	299.7	297.4	290.4	283.3	283.1	267.5	211.3	200.3	179.0
Experienced (Treatment average)	361.4	366.7	380.3	372.3	387.1	394.8	392.8	401.9	430.1	439.7	425.3	402.5	403.3	422.2	437.7	356.8
Permutation test (one-sided *p*-value)	0.1563	0.0781	0.0156	0.0313	0.0625	0.0781	0.0625	0.0781	0.0938	0.0781	0.1094	0.1719	0.1563	0.0313	0.0313	0.1875

APPENDIX 3: PERIOD-WISE TESTS OF MEDIAN TRANSACTION PRICE DIFFERENCES IN NOUSSAIR MARKETS

Incentive Effects in Inexperienced Noussair Markets																
Period	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Baseline (Treatment average)	359.0	372.5	381.3	399.3	384.8	398.8	403.9	402.8	391.3	400.3	398.8	400.4	401.3	399.5	400.8	399.5
Tournament (Treatment average)	461.3	462.4	456.5	447.8	442.8	444.9	440.0	437.5	436.5	431.0	382.0	430.0	427.5	418.4	419.0	415.9
Permutation test (one-sided *p*-value)	0.0143	0.0143	0.0143	0.0714	0.0143	0.0429	0.1429	0.0571	0.0429	0.0571	0.5571	0.0571	0.0714	0.0429	0.0571	0.0429
Incentive Effects in Experienced Noussair Markets																
Period	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Baseline (Treatment average)	400.3	400.5	400.8	400.0	400.0	399.8	399.8	399.8	400.0	400.3	399.8	400.5	400.3	398.4	399.1	396.5
Tournament (Treatment average)	421.8	421.5	421.3	420.0	419.3	418.8	418.9	419.0	419.0	418.9	419.3	418.8	418.3	418.0	416.5	412.8
Permutation test (one-sided *p*-value)	0.0714	0.0429	0.0714	0.0286	0.0286	0.0571	0.0571	0.0571	0.0714	0.0429	0.0143	0.0429	0.0571	0.0143	0.0286	0.0571