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Abstract

A simple model, based on the Binomial Theorem, is employed to predict that the probability of matching buyers and sellers increases with the number of transactions. The ask-bid spread, interpreted as a measure of liquidity, is assumed to vary negatively with the probability of matching buyers and sellers. The hypothesis addressed in this paper is that the ask-bid spread varies negatively with volume. This hypothesis is investigated for six contracts traded on the Sydney Futures Exchange from 1980 to 1991. The results support the hypothesis for the majority of contracts studied. The implication of these results is that futures trading can be expected to become concentrated geographically in a few key locations, and within exchanges in a few key contracts.

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INCREASING RETURNS TO LIQUIDITY IN FUTURES MARKETS

I

Key classical economists favoured the view that increasing returns were likely to be encountered in manufacturing activity. In *The Wealth of Nations* 1776 Adam Smith argued that an increase in demand would lower the prices of manufactured goods in the long run due to "new divisions of labour and new improvements of art", which result from increased "competition of the producers" (vol. 2, pp. 271-72). Hollander (1973, pp. 142-43) suggests that Smith's argument implies both a movement along, and a shift in the production function. Similarly, Ricardo in the *Principles of Political Economy* 1821 thought that economic progress would reduce the price of all commodities, except agricultural produce, due to division of labour, improvements in machinery and "increasing skill, both in science and art, of the producers", and he thought that in manufacturing, this effect would outweigh the tendency to rise of raw material inputs (vol. 1, pp. 93-94). John Stuart Mill in his *Principles of Political Economy* 1848 also thought that the larger the scale of manufacturing operations "the more cheaply they can in general be performed" (pp. 702-703). If these classical economists had observed economic activity in the late twentieth century, they may well have raised the question of increasing returns in relation to futures markets.

A popular answer to the question of why futures markets exist is that they provide facilities for risk management. Recently some scholars have differed from this view: for example, Williams (1986) argued that futures markets are established in response to a demand by agents for ways to borrow and lend commodities, while Veljanovski (1986, pp. 25-26) argued that these markets develop because they are a more efficient means of transferring property rights attached to price than alternative market forms. Notwithstanding this diversity of views about their emergence, the output of futures markets may be measured by the volume of transactions per period of time, or by the number of open positions (contracts) at a point in time.[1] These two measures of output are likely to be generally, but not necessarily perfectly correlated: for example, the growth of intra-day trading would be reflected in turnover, but not in open positiens at the end of the day. This paper focuses on volume of transactions (V) as a measure of production. It is assumed that increased output requires increased inputs of three types: these are brokerage services (B), clearing house services (S), and information (I). The costs of transacting in futures markets are first brokers' (commission) fees, second clearing house fees, and third the ask-bid spread.[2] The first two costs are charged direct to economic agents by brokers and clearing house respectively. The ask-bid spread is a cost of transacting, and would be expected to vary inversely with the liquidity of the market. If V is small, little information is processed, and the ask-bid spread will be large. On the other hand, as V increases more information is processed and the ask-bid spread becomes narrower. This spread is part of the cost of matching bids and offers: it is a cost to both buyer and seller, because it means that the buyer pays more, and the seller receives less than desired in order to execute a transaction (see also Tucker (1991, p. 87), Smith and Whaley (1994, pp. 438-39)).

Telser and Higinbotham (1977) employ the standard deviation of market clearing prices as a measure of market liquidity. They argue that the distribution of market clearing prices is asymptotically normal, and hence that the standard deviation of prices is a decreasing function of the square root of the number of transactions (p. 976).[3] On this basis, Telser (1981, p. 17) argues that there are increasing returns to liquidity.

II

This paper examines the question of increasing returns to liquidity. The ask-bid spread is employed as a measure of liquidity, and the hypothesis addressed is that the ask-bid spread is a decreasing function of volume. In recent years, considerable evidence has accumulated to support the view that price changes in securities and futures markets are not normally distributed, but are leptokurtic (e.g. Hsieh (1988), Hall *et al.* (1989), and Harris (1987)). In this paper, therefore, the increasing returns hypothesis is based on the concept of increasing probability of success, for an economic agent, as volume increases. For a potential buyer, **success** is defined as an ask price sufficiently close to the bid price for a transaction to occur; a corresponding definition is employed for a potential seller. **It is assumed that the probability of success is given by the Binomial Distribution.** The probability of x successes is given by:

$$f(x) = \frac{n!}{x!(n-x)!} p^x q^{n-x} \tag{1}$$

where x = number of successes;

n = number of trials;

p = probability of success (in a single trial);

q = probability of non-success.

Substitution in (1) shows that the probability of zero successes decreases as *n* increases; hence the probability of one or more successes increases with *n*. **It is assumed that the ask-bid spread varies negatively with the probability of one or more successes.**

The hypothesized negative relationship between volume and ask-bid spread is represented by the linear relationship

$$V_t = \alpha_0 + \alpha_1 ABP_{t,t+i} + e_t \qquad (2)$$

where V = volume in contracts;

ABP = ask-bid spread;

t = time in months;

t+i = delivery date of futures contract; (i = 2,5: see below);

e = error term;

α_0 = constant; $\alpha_1 < 0$.

In this paper the quoted ask-bid spread is employed, rather than the effective spread: the latter can not be observed directly (although it can be estimated from intra-day data; see Wang *et al.* (1994), Smith and Whaley (1994). Nevertheless, intra-day ask-bid spread data are not accompanied by volume data[4] The ask-bid spread quotations used here are observed on the median trading day of each month, and trading volume, in number of contracts, is observed on the same day.

While the world's two leading futures exchanges, the Chicago Board of Trade and the Chicago Mercantile Exchange, do not publish ask and bid quotations, the Sydney Futures Exchange (SFE) ranked ninth in the world by volume in 1992, published daily ask and bid prices in its *Statistical Yearbook* from 1980 through 1991, from which the data employed in this paper have been obtained. The contracts studied are those for 90 Day Bank Accepted Bills (BAB), Ten Year Bond, All Ordinaries Share Price Index (SPI), and US Dollar, traded on the SFE. The first three are examples of current, successful contracts; the first two frequently trade in excess of 20,000 lots daily, while the third typically traded less than 5,000 lots daily during the sample period (although in 1995 average daily volume for the SPI contract exceeded 9,000 contracts). The US Dollar contract had limited success, then traded thinly, and was subsequently delisted. It is included here for purposes of comparison; the hypothesis tested is presumably reversible, and the ask-bid spread would be expected to widen as volume declines. While all four contracts have maturity dates in March, June, September and December each year, only the BAB contract provides for delivery, the other three providing for mandatory cash settlement. Only the BAB and SPI contracts have developed liquidity which extends beyond the spot month (contract nearest to delivery), so that for these two contracts the spot month and near future (second closest to delivery) are studied, while for the 10 Year Bond and US Dollar, spot month contracts only are included.

III

The ask-bid spread (ABP) is defined as [(ask price-bid price)/bid price] $\times 10^3$. These prices are observed on the median trading day of the month. Prices for BAB and 10 Year Bond contracts are quoted as (100 **minus** yield), prices for SPI are quoted as index, while for the US Dollar contract prices are quoted as Australian cents per US dollar. Volume (V) is measured by the number of contracts traded, and is observed on the median trading day of the month. For **spot** month contracts, observations are made

two months prior to delivery, while for **near** futures observations are made **five** months prior to delivery.

While the basic sample period is (01) 1980 to (12) 1991, after allowance for differing dates of inception, lags in the selection of instruments for estimation, and delisting in the case of the US Dollar contract, the respective numbers of observations for these contracts are as follows: BAB spot month (41 observations), BAB near future (40), 10 Year Bond (26), SPI spot month (33), SPI near future (34), US dollar spot month (29).[5]

To investigate whether the ask-bid spread and volume variables are stationary, Augmented Dickey-Fuller (ADF) tests for unit roots were conducted, using the following general model:

$$\Delta Z_t = \mu + \beta t + \gamma Z_{t-1} + \phi_j \Delta Z_{t-j} + e_t \qquad (3)$$

where Z is an economic variable;

μ = constant;

γ, β, ϕ_j are coefficients to be estimated;

j = 1, 2, ..., k;

e_t is assumed to be NID$(0,\sigma^2)$.

Inclusion of a time trend and lagged values of ΔZ_t in the model for a specific test depends on whether those variables are significant, and on whether serial correlation remains in e_t. The hypothesis of a single unit root in Z_t is addressed by testing the hypothesis H(γ=0) in (3). In the tests reported in this paper a ten per cent level of significance has been employed, first, because of the acknowledged low power of these samples. Table 1 (columns 1 to 4) presents calculated ADF statistics, together with 10% critical values (from MacKinnon, 1991) for the ask-bid spread and volume for the six contracts studied here. It can be seen that for the BAB and US Dollar contracts, both ask-bid spread and volume are integrated I(1), while for both SPI contracts, the spread and volume are stationary. For the 10 Year Bond contract, however, only the spread is stationary, volume being I(1). (Phillips-Perron tests for unit roots also were conducted: see Appendix.)

In the case of the BAB and US Dollar contracts, where both ask-bid spread and volume are I(1), the question is, therefore, whether ABP and V are cointegrated. To address this question, the hypothesis of no cointegration was tested using the Augmented Engle Granger (AEG) test. In columns 5 and 6 of Table 1, which provides calculated AEG statistics, together with 10% critical values, it can be seen that the hypothesis of no cointegration is rejected for BAB spot month and US Dollar contracts, but not for BAB near future. To render the regression residuals stationary in the spread-volume relationship for the BAB near future, therefore, first differences of both variables were taken, and the relationship was estimated in the form

$$\Delta V_t = \alpha_0 + \alpha_1 \Delta ABP_{t,t+i} + e_t \qquad \text{(2A)}$$

In the case of the 10 Year Bond contract, where volume only is I(1), the first difference of volume was taken, and the relationship was estimated as

$$\Delta V_t = \alpha_2 + \alpha_3 ABP_{t,t+i} + e_t \qquad \text{(2B)}$$

For the BAB spot month, SPI and US Dollar contracts, the spread-volume relationship was estimated as in (2).

The estimation of (2), (2A), (2B) was executed by instrumental variables (IV), in the presence of an endogenous regressor, with a correction for first order autocorrelation in the case of both BAB contracts, and SPI spot month contract. In (2) and (2A) the increasing returns hypothesis requires $\alpha_1<0$, while in (2B) it requires $\alpha_3<0$. All estimations reported in this paper were executed by E-Views (Hall *et al.*, 1994).

Parameter estimates for equations (2), (2A), (2B) are presented in Table 2, together with asymptotic *t* values, and the Durbin-Watson statistic, which is included for informal comparison only with IV estimation. It can be seen that there is support for the increasing returns hypothesis in the case of four of the six contracts in the sample (BAB near future, SPI spot month and near future, and US Dollar), where estimates of α_1 are negative and significant at the 5% level (one tail test). In the case of the BAB spot month contract, there appears to be a negative relationship between ask-bid spread and volume, but this is not significant. For the 10 Year Bond contract, an apparently negative relationship between changes in ask-bid spread and the **rate of change** of volume (see (2B)) is not significant.

In any case, there is clear support for the view that the ask-bid spread varies negatively with volume, and hence for the hypothesis of increasing returns to liquidity, for the BAB near future, SPI spot month and near future, and US Dollar contracts. In the first two contracts, volume has exhibited strong growth during the sample period, while for the third contract volume has fluctuated widely without a clear trend. In the last case, volume has shown modest growth and decline during the sample period.

The main policy implication of these results is that futures trading could be expected to become concentrated geographically in a few key locations, and within

exchanges in a few key contracts. This is consistent with the arguments of Telser and Higinbotham (1977, p. 976) and Veljanovski (1986, pp. 34-5), and with market developments in the USA, Europe and Australia. In the USA futures trading is dominated by three major exchanges (CBOT, CME and NYMEX), which exhibit some contract differentiation. In Western Europe, when *The Economist* (June 18, 1988, p. 77) predicted the proliferation of futures markets post 1992, it might well have predicted the demise of most of the smaller markets, with LIFFE, MATIF and DTB dominating trading in financial futures.[6] Indeed, this seems to be foreshadowed in subsequent articles in *The Economist*: see September 21, 1991, p. 104; September 17, 1994, p. 84; September 7, 1996, p. 81 (see also December 14, 1996, p. 92, where the same point is made in relation to Asian exchanges). On the Sydney Futures Exchange, while three interest rate contracts and one share price index contract were ranked within the top twelve world wide in 1994, most commodity contracts have traded thinly during the past decade. Promoters of futures contracts and exchanges, therefore, should be wary of proliferation, unless there is clear evidence of product differentiation with respect to content or time zone, although the latter is of reduced importance with the growth of global trading.

While the data set employed in this paper includes all leading financial futures contracts traded on the SFE, apart from the 3 Year Bond contract (which began trading in May 1988), all the data refer to one exchange. Moreover, while there is support for the increasing returns hypothesis for a majority of the contracts studied, the exceptions are not unimportant. For both these reasons, further study of this issue is warranted.

TABLE 1

UNIT ROOT AND COINTEGRATION TESTS

Contract/ Variable	Calculated ADF Statistic	10% Critical Value	Order of Integration	Calculated AEG Statistic	10% Critical Value
BAB Spot month				−6.230	−3.666
ABP	−1.779	−2.605	I(1)		
V	−1.233	−2.605	I(1)		
BAB Near Future				−1.931	−3.149
ABP	−1.801	−2.605	I(1)		
V	−1.692	−3.191	I(1)		
10 Year Bond				–	–
ABP	−5.344	−2.629	I(0)		
V	−2.959	−3.228	I(1)		
SPI Spot month				–	–
ABP	−4.374	−3.425	I(0)		
V	−3.559	−2.613	I(0)		
SPI Near Future				–	–
ABP	−2.823	−2.613	I(0)		
V	−5.251	−2.613	I(0)		
US Dollar				−5.116	−3.749
ABP	−1.134	−3.224	I(1)		
V	−2.287	−2.624	I(1)		

TABLE 2

Parameter Estimates: Equations (2), (2A), (2B)*

Equation/ Contract	$\alpha_0 ; \alpha_2$	$\alpha_1 ; \alpha_3$	ρ	N	Durbin-Watson Statistic
(2) BAB spot month	6704.840 (2.484)	–55.575 (-0.460)	0.616 (4.688)	41	2.362
(2A) BAB near future	177.630 (0.841)	–32.452 (–1.722)	–0.421 (–1.756)	40	2.261
(2B) Ten Year Bond spot month	5057.360 (1.541)	–594.033 (–1.312)	–	26	1.829
(2) SPI spot month	1763.992 (5.777)	–1608.318 (–2.073)	0.337 (2.073)	33	2.092
(2) SPI near future	134.181 (3.670)	–17.977 (–1.948)	–	34	2.256
(2) US Dollar spot month	152.799 (5.991)	–79.411 (–2.454)	–	29	1.626

*Asymptotic t values are in parentheses; ρ is the autocorrelation coefficient, and N is the number of observations.

ENDNOTES

[1] Futures exchanges do, however, produce other outputs, such as price quotations, education programs, and research seminars.

[2] Brokerage and clearing house services may be measured by time, while information input may be measured by number of client orders. It is assumed that the production function $V = f(B,S,I)$ is continuous and has continuous first and second order derivatives.

[3] Telser and Higinbotham (1977, pp. 995, 998) also found, in their sample of 51 commodities traded on US exchanges, that commission charges varied negatively with volume, but directly with open interest.

[4] The effective ask-bid spread as defined by Smith and Whaley (1994, p. 439) combines elements of transaction cost with the forecasting ability of the agent. This is because their definition of the effective spread takes account of the price at which a transaction is opened and the price at which it is closed.

[5] Actual sample periods are as follows: BAB (01) 1980 - (12) 1990; 10 Year Bond: (01) 1985 - (12) 1991; SPI: (04) 1983 - (12) 1991; US dollar: (04) 1980 - (07) 1987. The US Dollar contract was replaced, in February 1988, by the "Australian Dollar" contract, which provided for delivery, with prices quoted in US cents per Australian dollar. Data for this latter contract are not included in this paper.

[6] The key to these abbreviations is as follows: CBOT: Chicago Board of Trade; CME: Chicago Mercantile Exchange; NYMEX: New York Mercantile Exchange; LIFFE: London International Financial Futures Exchange: MATIF: Marche a Terme Internationale de France; DTB: Deutsche Terminborse.

APPENDIX

Phillips-Perron tests for unit roots also were conducted for the ask-bid spread and volume variables in this paper. Although not reproduced here for reasons of space, the results of these tests are available from the authors on request; they indicate that all variables are integrated I(0) at the 10% level of significance. The implication of these tests is that it was necessary to re-estimate the relationship between ask-bid spread and volume for the BAB near future and Ten Year Bond contracts, in level form. These relationships were estimated by IV, with a AR1 correction in the case of the Ten Year Bond. The parameter estimates are as follows (asymptotic *t* values in parentheses):

Contract	α_0	α_1	ρ	N	D-W
BAB near future	7044.70 (1.646)	−195.104 (−1.463)	–	43	1.905
10 Year Bond spot month	13585.7 (3.266)	−399.20 (−0.786)	0.376 (2.032)	25	1.610

While the estimates of α_1 are negative in both cases, neither is significant at the 5% level, so that in neither case is there clear support for the increasing returns hypothesis. In the case of the Ten Year Bond contract, this outcome is the same as that reported in the text; for the BAB near future, this outcome differs from the result in the text, thus leading to ambiguity about the result for that contract. Analysis of the residuals of the original equation reveals the presence of a negative moving average component in this latter case, so that the Phillips-Perron test is likely to be affected by size distortion (see Banerjee *et al*, 1993, pp. 108-109, 113, 129). For this reason the ADF tests are preferred for the BAB near future, and hence the regression results reported in the text are preferred for this contract.

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