The impact of technological improvements on developing financial markets: The case of the Johannesburg Stock Exchange

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Abstract

Can a significant technological improvement make an economically justifiable contribution to a financial market’s development? The Johannesburg Stock Exchange (JSE) incorporated the SETS system from the London Stock Exchange in 2002. It is certain that SETS is a technologically efficient trading system, and it would undoubtedly improve trading in the JSE. We test whether SETS represents a structural break by examining whether there was an increase in the JSE’s liquidity, market efficiency and international integration after the introduction of SETS. While SETS is certainly a technological improvement with increased liquidity, it is not a sufficient factor to render it efficient. After the incorporation of SETS, the JSE has become more independent and it now offers better diversification opportunities for international investors.

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1. Introduction

The mood was certainly buoyant at a celebratory dinner on 17 May 2002, where South African President Thabo Mbeki gushed about the Johannesburg Stock Exchange’s (JSE) new partnership with the London Stock Exchange (LSE). The partnership entailed the incorporation of the LSE’s SETS trading platform by the JSE. In obligatory political fashion, Mbeki proclaimed that the new trading platform,

will add the necessary impetus in our work of reconstructing and developing not only our country but the entire continent of Africa [by encouraging investment]. Strategic partnerships with a number of globally prominent companies [such as the one with LSE] have had the simultaneous impact of exposing the South African capital markets sector to the rest of the world, bringing world-class services and infrastructure to the JSE and entrenching the JSE in the mind of the international investor as the gateway into the African market (Mbeki, 2002).

The development of financial markets is important in facilitating economic development. For countries where access to capital is of the utmost importance, financial markets play a crucial intermediary role between savings and investment. If domestic and international banks are unable or unwilling to invest in such economies, capital can become scarce and prohibitively costly.

When developing countries try to develop their financial markets, five issues arise. (1) Protecting investors seems to be an a priori prerequisite for financial development (i.e. La Porta et al., 1998, 2000). (2) If the investment choice offers no diversification benefits, then there is limited reason for international investors to consider investing. If the major markets are the main drivers of returns, then the developing market does not offer a unique investment opportunity. While the return to risk ratio might be appealing, the market’s contribution toward diversifying a portfolio would be minimal. (3) Questionable market efficiency hampers the market’s development (Liu, 2010). There will be limited interest in the market by foreign investors if information is unavailable or asymmetric, or returns are predictable or
manipulatable. More importantly, there will be limited interest by local companies to be listed due to the associated inefficiency risks. (4) A lack of liquidity will hamper the development efforts. Institutional investment in emerging markets may be conditional on the availability of liquidity (Chuhan, 1992). Bekaedt et al. (2007) show that liquidity is a priced risk and part of the expected return model. Finally, (5) lack of trading activity (i.e. volume) implies a lack of interest in the market. With the diminishing interest, the expectation for market development will fade away.

In terms of financial market structure, the JSE’s adoption of SETS is a milestone for the JSE. SETS is a system used by the London Stock Exchange. Thus, its adoption should alleviate the five issues listed above for the development of the JSE and therefore for the development of the South African economy overall. (1) The anonymity of trades and traders allows higher investor protection. Institutions can trade without revealing their information, and individuals can trade without revealing their identity. (2) With a system that can accommodate a high number of listed companies, there will be more local companies listed. With diverse listed companies, unique opportunities for international investors will be offered by the JSE. (3) While SETS has a limited impact on the informational aspect of market efficiency, a system that can accommodate high transaction speeds, high number of market participants, and high volumes will increase market efficiency. (4) Having more investors and faster trades will provide liquidity (cheaper trades). Competition between investors will increase liquidity and lower the transaction costs. It will also allow for the emergence of market makers who in turn will provide liquidity. (5) A larger number of listed companies, investors, faster trades and cheaper trades will increase trading activity (volume).

In the present study, we examine the impact of SETS on the statistical properties of the JSE – in terms of returns, liquidity, and efficiency. Are returns in the JSE correlated with those in markets of more developed countries? In other words, is the JSE a good source of diversification? Are there inefficiencies in the South African exchange that could perhaps account for why even more capital does not find its way to Johannesburg? And just as importantly, has the incorporation of a more efficient trading platform paid off in terms of increased market efficiency and liquidity?

The paper is structured as follows. First, we explain why the JSE is of interest as a case study on market efficiency and development. We describe the institutional evolution of the JSE, pointing to a likely structural break in 2002. We follow this by reviewing the earlier empirical research on the JSE’s efficiency, potential for diversification, and structural breaks. Then, we perform several comparison-of-means tests of returns, liquidity, and volume. We also test for structural breaks of the predictability of returns (a test of market efficiency) and international integration. We conclude with a discussion of the implications of our study on equity markets in other developing countries.

2. The JSE and its performance

The JSE’s development sets an example for other, less developed, financial markets in the region. The JSE is the largest African stock market by a large margin. Its liquidity is growing, as is its relative size in terms of the world’s market capitalization (Jefferis and Smith, 2004).

Is the JSE relatively efficient? Earlier studies of the JSE’s market efficiency are largely inconclusive. Thompson and Ward’s (1995) paper reviews the literature on the efficiency of the JSE, finding that the studies differ over methodology, time periods, samples, and conclusions. In their words, “the evidence on the efficiency of the JSE is at best mixed, particularly regarding weak and semi-strong form efficiency” (p. 59), and generally is not strong-form efficient. For example, Glass and Smit (1995) conclude that the JSE is not semi-strong form efficient, while Jefferis and Okeahalam (1999) conclude that it is.

Ferret and Page (1998) analyzed four South African futures contracts and their corresponding spot market indices for cointegration. Ideally, these sets of equities should be perfectly correlated. Ferret and Page find a long-term linear relationship between these two sets of equities, but they also find that changes in the futures contracts lead those of the spot market by up to three days. This finding points to an exploitable lack of efficiency in the JSE.

While the studies before 2002 offered contradictory results, the studies conducted after 2002 tend to detect more efficiency than the earlier studies. For example, Jefferis and Smith (2004) find that large-cap indices are random walks and are weak-form efficient, whereas the smaller indices are not. Furthermore, among the 40 most capitalized individual stocks, and among the 40 most liquid small-cap stocks, 32 seem to follow random walks. Auer and Rudolph (2006) find that the announcement of CPI has no effect on stock prices, implying that the market is informationally efficient.

Overall, it seems that the JSE’s market efficiency has been increasing, perhaps, attributing to the incorporation of SETS in 2002. How well integrated is the JSE into the rest of the world’s equity markets? International markets provide options for diversification. Diversification can reduce risk while maintaining returns. In order to accomplish this, though, the varying assets must be uncorrelated so that changes in one will not necessarily offset the changes in another. If investment choices have the same return generating process, or they have a lead/lag relationship, then diversification cannot be achieved with these related instruments. The results to date have been mixed.


Several studies have investigated the integration of the various African stock exchanges. Piesse and Hearn (2002, 2005) and Teyandela and Biekpe (2001) find that the Southern African stock exchanges are highly integrated, while Hearn and Piesse (2008) find some integration only between selected pairs of countries. Samouilhan (2006) finds that the JSE and LSE move almost simultaneously; if there is a causal effect from one market to another, Samouilhan hypothesizes that the causation happens at a frequency that is higher than daily data can reveal. He restricts his sample to daily data on broad aggregate and sectoral indices.
3. Structural breaks and the evolution of JSE

In determining their sample period, many researchers simply opt for the longest time series available. However, this might not be appropriate, as there may be structural changes in the series, so that the market before these changes has little relationship to its performance afterwards. Moreover, structural breaks may be confused econometrically with non-stationarity. Not accounting for the possibility of structural breaks could, therefore, lead to misleading conclusions (Dicle and Dicle, 2010). If SETS marks a true structural break, its effect should be accounted for in order to avoid omitting variables.

There have been several structural reforms in the JSE over the past two decades. Understanding these helps isolate the effects of SETS by not including the possibly confounding effects of other reforms.

Until the 1990s, the JSE was burdened by several structural inefficiencies which diminished its ability to allocate capital. One such example was its dual exchange rate system – a type of exchange rate control – which was eliminated in 1995. Foreign ownership and limited liability corporate membership were allowed in 1995 (Jefferis and Smith, 2004).

Looking at changes in the bid-ask spreads of 135 stocks on the JSE from 1991 to 1996, Michello (2001) examines evidence for structural changes on three events: (1) April 1, 1991, when the tax rate on marketable securities was dropped from 1.5% to 1.0%, (2) April 27, 1994, when an elected national-unity government was established, and (3) March 13, 1995, when the government eliminated the exchange rate controls. Michello did not find any structural breaks on these dates. Given that these seemingly important changes had no appreciable effect on the JSE, the deck is certainly stacked against the importance of SETS. In light of this, if it were found that SETS had an impact on the JSE’s development, then it was of huge value to South Africa, and it could be argued that other countries should adopt similar trading platforms.

Makina and Negash (2005) investigate the possibility of a structural break in the JSE in 1995. Using data on real aggregate stock prices, they find a break significantly earlier than the legal date of liberalization. The authors argue that the market had already anticipated the forthcoming reforms by December 1992.

In the span of less than 10 years, the JSE has become “one of the most technologically advanced emerging markets” (Jefferis and Smith, 2004, p. 690). In 1996, the JSE began transitioning toward fully electronic trading. In 1997, an electronic news service was introduced, which reported price-relevant information in real time.

On 13 May 2002, the JSE began using the London Stock Exchange’s SETS electronic trading system. According to Rus- sel Loubser, the head of the JSE, this technologically advanced trading platform is “more functional and reliable and stable” (BBC, 2002). Moreover, it allows for anonymous trading, which should increase the market’s liquidity and, through this liquidity, increased efficiency. This is because anonymity gives comfort to even small investors, and allows larger investors to trade larger blocks of shares discreetly. An institutional herding effect can be a source of market inefficiency. If individual investors follow institutional investors, whom they presume are better informed, then the market can be manipulated by those institutions. Institutions also become reluctant to invest to avoid revealing their information. Institutional stealth trading has received considerable attention in the literature (ex. Blau et al., 2009). The new trading platform also has the potential to allow dual primary listings in several exchanges.

Given the important changes that occurred throughout the 1990s in South Africa, we restrict our attention to January 1997 to December 2007. The incorporation of SETS into the JSE sits at the middle of this range.

4. Data

The data for the study are from Thomson’s Reuters, using the Quotecenter application for the period between January 1997 to December 2007. We restrict our attention to ordinary stocks. We follow Chordia et al. (2000) in filtering our data to remove equities whose price puts them at the tails of the distribution. Thus, stocks whose price is 100 times above the daily average are excluded; stocks whose price is <1% of the daily average are also excluded. In a similar manner, any observations whose returns, or percentage spread fall five or more standard deviations from the mean are excluded from the sample.

Returns can be calculated using either close-to-close prices or open-to-close prices. Returns, calculated on a close-to-close basis, are denoted by \( \text{RCC}_{i,t} \), and are computed as:

\[
\text{RCC}_{i,t} = \ln \left( \frac{P_{i,t}}{P_{i,t-1}} \right)
\]

where \( P_{i,t} \) is the dividend and split-adjusted price of stock \( i \) at time \( t \). Open-to-close returns are denoted \( \text{ROC}_{t,i} \), and are calculated analogously.

We calculate percentage bid and ask spreads of stock \( i \) at time \( t \) as:

\[
\text{PRS}_{i,t} = \frac{\text{Ask}_{i,t} - \text{Bid}_{i,t}}{P_{i,t}}
\]

where \( \text{Ask}_{i,t} \) and \( \text{Bid}_{i,t} \) refer to the daily closing ask and bid prices, respectively, of stock \( i \) on day \( t \).

When we turn to detecting Granger causality from other markets, we must restrict ourselves to looking at market averages.

\footnote{In an earlier version of the paper, the sample began at year 2000, so that all of the tumultuous 1990s were excluded. Expanding our sample did not change the results in any meaningful way, so at the suggestion of a referee, we opted for the larger sample. Results from the restricted sample are available from the authors upon request.}

\footnote{Close-to-close returns include price reaction to information during the trading hours and during the period between previous day’s closing and daily opening. Open-to-close returns, on the other hand includes price reaction only to the information during the trading hours.}
Comparison of pre- and post- SETS. Data are through Reuters, using the Quotecenter application for the period January 1997 until December 2007. *** and **** refer to statistical significance at the 10%, 5% and 1% level, respectively.

<table>
<thead>
<tr>
<th></th>
<th>μpre</th>
<th>μpost</th>
<th>t</th>
<th>pre &gt; post</th>
<th>pre ≠ post</th>
<th>pre &lt; post</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily returns</td>
<td>0.0004</td>
<td>0.0015</td>
<td>3.13</td>
<td>***</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td>Liquidity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Illiquidity</td>
<td>0.0000</td>
<td>0.0001</td>
<td>2.51</td>
<td>**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quoted spread</td>
<td>32.0360</td>
<td>53.7889</td>
<td>3.99</td>
<td>***</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td>Proportional quoted spread</td>
<td>0.0650</td>
<td>0.0548</td>
<td>−3.77</td>
<td>***</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td>Effective spread</td>
<td>30.8118</td>
<td>48.6188</td>
<td>3.73</td>
<td>***</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td>Proportional effective spread</td>
<td>0.0642</td>
<td>0.0522</td>
<td>−4.41</td>
<td>***</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td>Volume</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Volume</td>
<td>251,940</td>
<td>475,791</td>
<td>6.71</td>
<td>***</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td>Relative volume</td>
<td>0.0008</td>
<td>0.0004</td>
<td>−2.72</td>
<td>***</td>
<td>***</td>
<td>***</td>
</tr>
</tbody>
</table>

(rather than causality between thousands of individual stocks). One may calculate (equal-weighted, or value-weighted) returns of all JSE stocks. We calculate equal-weighted, close-to-close returns as the simple sum of the returns from each stock in exchange ċ:

\[
\text{EWRCC}_{c,t} = \sum_{i \in ċ} \ln \left( \frac{P_{i,t}}{P_{i,t-1}} \right) \quad (3)
\]

Value-weighted returns are:

\[
\text{VWRCC}_{c,t} = \sum_{i \in ċ} P_{i,t} Q_{i,t} \ln \left( \frac{P_{i,t}}{P_{i,t-1}} \right) / \sum_{i \in ċ} P_{i,t} Q_{i,t} \quad (4)
\]

where returns of each stock in market ċ are weighted by the value of its shares outstanding (price times quantity) as a percentage of the listing markets’ total capitalization. Open-to-close returns are calculated similarly, with the appropriate modifications.

The variable SETS, is a binary variable that is equal to 1 if SETS was in place during period t, and 0 if otherwise.

Finally, two binary variables, large and small, are to capture the size effect. We sort the companies based on their market capitalization into quintiles. The binary variable large is assigned a value of one if the company is in the top two quintiles and zero otherwise. The binary variable small is assigned a value of one if the company is in the bottom two quintiles and zero otherwise.

5. Empirical results

Thoroughly analyzing the effect of SETS on the JSE requires looking at two different levels of data: (1) the overall market level, and (2) the level of individual stocks. Griffin et al. (2010) evaluate individual stocks as well as portfolios for their market efficiency tests. This is especially necessary for smaller exchanges, as what might appear to be a market-wide phenomenon might actually be the result of a few high-valued and/or high volume stocks. Evaluation of individual stocks also allows us to examine the effect of SETS on certain stock characteristics. This would be of interest for exchanges other than the JSE which list stocks with similar characteristics.

First, we conduct simple comparison-of-means tests to see whether returns, liquidity and volume have changed pre- vs. post-SETS. We report these results in Table 1. In the first row, we see that daily returns are, on average, nearly three times higher after the incorporation of SETS. While higher returns imply higher compensation for market participants, they can also imply higher risk. However, given that prices and volume have both increased, the more likely cause for the increase is an improved demand for South African listed securities.

In rows two through six, we examine whether the JSE has become more or less liquid after SETS. Two (inverse) measures of liquidity, the proportional quoted spread and proportional effective spread have decreased, implying that the JSE has become more liquid for international institutional investment.4,5 Trading activity (volume) has nearly doubled for JSE after SETS compared to the period before SETS.

Our analysis continues with formal econometric testing of returns, liquidity and market independence. Efficient markets are characterized by unpredictable returns (most likely as random walks). Fama (1970) argues that autocorrelated returns indicated an inefficient market. If today’s returns in the JSE are predictable, i.e. dependent upon lagged returns, then this is evidence that the JSE is inefficient. Griffin et al. (2010) also employ an autocorrelation test of returns to evaluate market efficiency. With the adoption of SETS, the expectation is toward a more efficient market, therefore toward less predictable returns.

Hypothesis 1. SETS had an impact on overall market returns.

We test whether SETS had any impact on the returns process of the JSE using the GARCH(1,1) model below:

\[
\text{WR}_t = \left( \beta_0 + \beta_1 \text{WR}_{t-1} + \beta_2 \text{WR}_{t-2} + \beta_3 \text{PRS}_t + \beta_4 \text{PRS}_{t-1} \right) \cdot \left( 1 - \text{SETS} \right) + \left( \gamma_0 + \gamma_1 \text{WR}_{t-1} + \gamma_2 \text{WR}_{t-2} + \gamma_3 \text{PRS}_t + \gamma_4 \text{PRS}_{t-1} \right) \cdot \left( \text{SETS} \right) + \varepsilon_t + \varepsilon_t \sim N(0, \sigma_t^2)
\]

\[
= \lambda_0 + \lambda_1 \varepsilon_{t-1}^2 + \lambda_2 \varepsilon_{t-1}^2 \quad (5)
\]

4 Amihud’s measure of illiquidity (row 2), has increased after SETS. Since the data includes many non-trading days and illiquid stocks with limited trading activity, Amihud’s illiquidity ratio is affected by this lack of trading activity.

5 Since the price levels are increasing in the JSE, even though the proportional quoted spreads are decreasing, the quoted spreads are increasing. We included the quoted and effective spreads to show the spread magnitudes. The proportional measure of liquidity is preferred since JSE listed stocks have increased in price since 1997.
Table 2
Evaluation of market level returns for the Johannesburg Stock Exchange. The results provided in this table are obtained using Eq. (5):
\[ W_R = (\beta_0 + \beta_1 W_{t-1} + \beta_2 W_{t-2} + \beta_3 PRS_t + \beta_4 PRS_{t-1}) \times (1 - SETS) + (\gamma_0 + \gamma_1 W_{t-1} + \gamma_2 W_{t-2} + \gamma_3 PRS_t + \gamma_4 PRS_{t-1}) \times (SETS) + \epsilon_t, \]
where \( \epsilon_t \sim N(0, \delta_t^2) \) and \( \delta_t^2 = \lambda_0 + \lambda_1 \delta_{t-1}^2 + \lambda_2 \delta_{t-1}^2. \) Data are through Reuters, using the Quotecenter application for the period January 1997 until December 2007. \( W \) refers to either equally weighted (EW) or value weighted (VW); likewise, \( R \) refers to either close-to-close (RCC) or open-to-close (ROC) returns. PRS refers to the percentage spread as the measure of liquidity. "*", "**", and "***" refer to statistical significance at the 10%, 5% and 1% level, respectively.

<table>
<thead>
<tr>
<th></th>
<th>5 years before and after SETS</th>
<th>3 years before and after SETS</th>
<th>1 year before and after SETS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RCC</td>
<td>ROC</td>
<td>RCC</td>
</tr>
<tr>
<td></td>
<td>EW</td>
<td>EW</td>
<td>EW</td>
</tr>
<tr>
<td>Pre-SETS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \beta_0 )</td>
<td>-0.0009***</td>
<td>0.0000</td>
<td>0.0009***</td>
</tr>
<tr>
<td>( \beta_1 )</td>
<td>0.1934***</td>
<td>0.3331***</td>
<td>0.1327**</td>
</tr>
<tr>
<td>( \beta_2 )</td>
<td>0.2227***</td>
<td>0.3150***</td>
<td>0.0625**</td>
</tr>
<tr>
<td>( \beta_3 )</td>
<td>-0.0059***</td>
<td>-0.0067**</td>
<td>-0.0071***</td>
</tr>
<tr>
<td>( \beta_4 )</td>
<td>0.0000</td>
<td>0.0003</td>
<td>-0.0031**</td>
</tr>
<tr>
<td>Post-SETS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \gamma_0 )</td>
<td>0.0006***</td>
<td>0.0012***</td>
<td>0.0010***</td>
</tr>
<tr>
<td>( \gamma_1 )</td>
<td>0.0403</td>
<td>0.1372***</td>
<td>0.1014**</td>
</tr>
<tr>
<td>( \gamma_2 )</td>
<td>0.0836***</td>
<td>0.1077***</td>
<td>0.0115</td>
</tr>
<tr>
<td>( \gamma_3 )</td>
<td>0.0002</td>
<td>-0.0027**</td>
<td>-0.0011</td>
</tr>
<tr>
<td>( \gamma_4 )</td>
<td>0.0005</td>
<td>-0.0024**</td>
<td>0.0007</td>
</tr>
<tr>
<td>( \delta_t^2 )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \lambda_0 )</td>
<td>0.0000***</td>
<td>0.0000***</td>
<td>0.0000***</td>
</tr>
<tr>
<td>( \lambda_1 )</td>
<td>0.0700***</td>
<td>0.0711***</td>
<td>0.1102***</td>
</tr>
<tr>
<td>( \lambda_2 )</td>
<td>0.9169***</td>
<td>0.9183***</td>
<td>0.8681***</td>
</tr>
</tbody>
</table>

208
This type of regression specification allows the data generating process to vary pre- and post-SETS. (Including only one SETS dummy additively would restrict the betas and gammas to be equal.) The above model could also be tested using a simple t-test to compare returns before SETS and returns after SETS. In effect, it is essentially the same. However, since the effect of conditional heteroscedasticity on returns is well established in the financial literature, we employ a GARCH(1,1) model. Griffin et al. (2010) employ variance ratio tests as part of their market efficiency evaluation across emerging markets. By employing GARCH(1,1), we condition the past volatility and implement it in all our tests of market efficiency.

For the sake of simplicity, we provide the estimating equation in general form. That is, for each of the equations W refers to either equal-weighted (EW) or value-weighted (VW); likewise, R refers to either close-to-close (RCC) or open-to-close (ROC) returns.

In Table 2 we explore all of the possible permutations of these choices: value-weighted and equal-weighted returns, calculated on open-to-close and close-to-close prices.

We consider three different windows (i.e., 5 years, 3 years, and one year) before and after SETS. The results are consistent with the varying windows. As robustness checks Table 3 repeats the test using other liquidity measures, including effective spread, proportional effective spread and proportional quoted spread. The results are consistent across the different measures of liquidity.

The difference between $\beta_0$ and $\gamma_0$ is not statistically significant, except of equal-weighted open-to-close market averages, implying similar return levels before and after SETS. In sum, the empirical results point to the impact of SETS on overnight returns to be different for large and small stocks. SETS had a positive impact on intraday returns.

Fama (1970) argues that market efficiency is violated with deviations from random walks. We therefore evaluate factors that would be likely to affect returns, especially for a developing market such as JSE. Bekert et al. (2007) show the impact and predictive power of liquidity on returns in emerging markets. Brockman et al. (2009) find commonality in liquidity for a sample of countries that include emerging markets.

The relationship between the returns and liquidity is statistically significant before SETS, for both equal-weighted and value-weighted market averages. This implies that liquidity is important for small and large stocks. However, after SETS, statistical significance between returns and liquidity exists only for equal-weighted market averages. After SETS, liquidity is important for smaller stocks only. Also, before SETS, only the contemporaneous return-liquidity relationship exists. On the other hand, after SETS, this relationship, for equal-weighted market averages, persists contemporaneously as well as for the first lag. While there cannot be a definite explanation for this persistence, we argue that the evidence may reflect investors’ preference for continual liquidity for smaller stocks.

Overnight returns may be affected by overnight news and information releases, possibly international news. Intraday returns may be affected by movements in correlated markets. With equal-weighted returns, the weight of smaller stocks is higher since there are more smaller stocks than larger stocks; with value weighted returns, the weight of larger stocks is higher. Lower coefficients on lagged returns would make it harder to take advantage of return predictability, especially considering trading costs. Intraday returns are less predictable after SETS; this is also true for overnight returns, but only for larger stocks (value-weighted market returns). This would imply that, after SETS, it may be possible to take advantage of overnight returns for smaller stocks, a sign of market inefficiency.

The results remain qualitatively similar when we employ alternative liquidity measures.

**Hypothesis 2.** SETS had an impact on individual stock returns.

We test whether SETS had an impact on individual returns using the dynamic panel data model below:

\[
\text{Ret}_{i,t} = (\beta_i + \beta_0 \text{Ret}_{i,t-1} + \beta_2 \text{Ret}_{i,t-2} + \beta_3 \text{VWRet}_t + \beta_4 \text{VWRet}_{t-1} + \beta_5 \text{VWRet}_{t-2} + \beta_6 \text{PRS}_{i,t} + \beta_7 \text{PRS}_{i,t-1} + \beta_8 \text{Small}_{i,t} + \beta_{10} \text{Large}_{i,t}) \cdot (1 - \text{SETS}) + (\gamma_1 + \gamma_0 \text{Ret}_{i,t-1} + \gamma_2 \text{Ret}_{i,t-2} + \gamma_3 \text{VWRet}_t + \gamma_4 \text{VWRet}_{t-1} + \gamma_5 \text{VWRet}_{t-2} + \gamma_6 \text{PRS}_{i,t} + \gamma_7 \text{PRS}_{i,t-1} + \gamma_8 \text{PRS}_{i,t-2} + \gamma_9 \text{Small}_{i,t} + \gamma_{10} \text{Large}_{i,t}) \cdot (\text{SETS}) + \epsilon_t \sim N(0, \sigma^2) \cdot \sigma_t^2
\]

That is, the return of a stock listed on the JSE is a function of its own returns, the overall (value-weighted) market’s returns, and two dummy variables indicating whether the stock is relatively small or large. Coefficients are allowed to vary pre- vs. post-SETS. This GARCH model is also equivalent to a simple t-test to compare individual stock returns before SETS to individual stock returns after SETS.

The dependent variable is individual stock returns, so we need not worry about value-weighting or equal-weighting returns for Ret$_{i,t}$. However, in order to control for the overall market’s returns, we condition on value-weighted returns (measured on an open-to-close and close-to-close basis). We also consider the effect of stock size on the returns-generating process. That is, smaller stocks might behave differently than large stocks, especially in emerging markets. As this is a panel data model, each stock assumes its own idiosyncratic risk, with its own idiosyncratic return $\beta_i$ (and $\gamma_i$ post-SETS). A Hausman test with 1% statistical significance indicates that the random effects, rather than fixed effects, variant of the model should be estimated. Results are shown in Table 4.

Column (1) of Table 4 estimates the panel model conditional on open-to-close market returns without controls for stock size, and compares the process pre- and post-SETS. Column (2) estimates the same model, but uses close-to-close returns. Columns (3) and (4) re-estimate the first two columns, but add the size variables. The results are largely consistent across all specifications.
Evaluation of market level returns for the Johannesburg Stock Exchange. The results provided in this table are obtained using Eq. (5): \( WR_t = (\beta_0 + \beta_1 WR_{t-1} + \beta_2 WR_{t-2} + \beta_3 PRS_t + \beta_4 PRS_{t-1}) \times (1 - SETS) + (\gamma_0 + \gamma_1 WR_{t-1} + \gamma_2 PRS_t + \gamma_3 PRS_{t-1}) \times (SETS) + \varepsilon_t \), where \( \varepsilon_t \sim N(0, \delta^2_t) \) and \( \delta^2_t = \lambda_0 + \lambda_1 \delta^2_{t-1} + \lambda_2 \beta^2_{t-1} \). Data are through Reuters, using the Quotecenter application for the period January 1997 until December 2007. \( W \) refers to either equally weighted (EW) or value weighted (VW); likewise, \( R \) refers to either close-to-close (RCC) or open-to-close (ROC) returns. \( PRS \) refers to the measure of liquidity; effective spread, proportional effective spread and proportional quoted spread. \( * \), \( ** \) and \( *** \) refer to statistical significance at the 10%, 5% and 1% level, respectively.

<table>
<thead>
<tr>
<th></th>
<th>Effective spread</th>
<th>Proportional effective spread</th>
<th>Proportional quoted spread</th>
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<tr>
<td></td>
<td>RCC</td>
<td>VW</td>
<td>EW</td>
</tr>
<tr>
<td>Pre-SETS</td>
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<td></td>
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<tr>
<td>( \beta_0 )</td>
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<td>0.0000</td>
<td>0.0009***</td>
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<tr>
<td>( \beta_1 )</td>
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<td>( \beta_2 )</td>
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<td>0.3175***</td>
<td>0.0576**</td>
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<tr>
<td>( \beta_3 )</td>
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<td>0.0015**</td>
<td>0.0001</td>
</tr>
<tr>
<td>( \beta_4 )</td>
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<td>0.0005</td>
<td>0.0005</td>
</tr>
<tr>
<td>Post-SETS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \gamma_0 )</td>
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<td>0.0012***</td>
<td>0.0010***</td>
</tr>
<tr>
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<td>0.1434***</td>
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<tr>
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<td>0.0003</td>
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<tr>
<td>( \gamma_4 )</td>
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<tr>
<td>( \delta^2_t )</td>
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<tr>
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<tr>
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<td>0.9196***</td>
<td>0.8668***</td>
</tr>
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</table>

Table 3

Market returns have both contemporaneous and lagged effects on intraday individual stock returns, but only its contemporaneous effect is statistically significant for overnight returns. After controlling for the market’s return, the intraday predictability of individual stock returns (using its own lagged returns) is increased after SETS (the coefficient almost doubles). This finding contradicts those at the market level. For overnight returns, the lagged market returns lose their statistical significance and contemporaneous returns have lower coefficients compared to intraday returns. Accordingly, the lagged returns of individual stocks increase and change sign. This would imply that JSE stocks are affected by their own market during the trading day, and this effect is smaller for overnight returns.

**Hypothesis 3.** SETS had a positive impact on smaller stocks’ returns.

Columns (3) and (4) of Table 4 allow for the investigation of Hypothesis 3, that SETS had a differential impact on stocks. The idea is that a more efficient trading system would allow for greater investments in smaller, more obscure stocks, so that their returns would be higher. The coefficients on the “small” variable, between the pre-SETS and post-SETS samples are, however, not statistically significant.

In summary, SETS exhibited a significant impact on JSE stocks. It increased the predictability of intraday returns, but reduced that of overnight returns. We cannot conclude that the JSE has become more efficient after SETS either at the market level or at the individual stock level.

**Hypothesis 4.** SETS changed whether foreign markets Granger-cause the JSE.

In order to investigate this hypothesis, we estimate the following model:

\[
WR_t = (\beta_0 + \beta_1 WR_{t-1} + \beta_2 WR_{t-2} + \beta_3 PRS_t + \beta_4 PRS_{t-1} + \beta_5 Foreign_{t-1} + \beta_6 Foreign_{t-2}) \cdot (1 - \text{SETS})
+ (\gamma_0 + \gamma_1 WR_{t-1} + \gamma_2 WR_{t-2} + \gamma_3 PRS_t + \gamma_4 PRS_{t-1} + \gamma_5 Foreign_{t-1} + \gamma_6 Foreign_{t-2}) \cdot \text{(SETS)}
+ \epsilon_t
\]

where \(\text{Foreign}\) refers to market returns in the foreign market being considered. We perform this test for 30 different exchanges. Similar to the previous tests, GARCH (1,1) is employed instead of a t-test since GARCH is superior for modeling daily equity returns.

Summary of the results from thirty foreign markets is contained in Table 5. This table simply shows whether the foreign market Granger-caused the Johannesburg market prior to or following the introduction of SETS. Specifically, it reports the
results of a Wald Chi² test of $\beta_3 = \beta_6 = 0$ against the alternative that either $\beta_3$ or $\beta_6 \neq 0$. We also do the same for the post-SETS coefficients, the $\gamma$s. We then compare whether the JSE was Granger-caused by more foreign markets before or after SETS.

Using equal-weighted open-to-close returns, 18 of 30 exchanges Granger-caused the JSE before SETS, while only 7 did after SETS. Using close-to-close returns, 26 of 30 exchanges Granger-caused the JSE before SETS, and only 7 did after. Using value-weighted returns, the results are less consistent. Using open-to-close returns, 10 of 30 exchanges Granger-caused the JSE before SETS, and 13 did after SETS. Using close-to-close returns, 16 exchanges caused the JSE before SETS, and 13 did after SETS. In summary, three of the four measures of market-level returns indicate that the JSE has become more independent of foreign exchanges.

Based on these results, we interpret that the incorporation of SETS has actually increased the independence of the Johannesburg Stock Exchange, thereby increasing its diversification benefits for international investors.

6. Conclusion

The adoption of the SETS trading platform was supposed to represent a watershed moment in the history of the Johannesburg Stock Exchange. The JSE is more liquid after SETS. The JSE has nearly doubled its trading activity (volume), trading is cheaper, and there are more trades at JSE after SETS.

Overall, average daily returns are higher. We posit that this is mainly because the returns are increased to the levels demanded for the associated risk. With the new trading platform, it would also be expected that there would be improvements in market efficiency. Higher numbers of investors, more listed companies, faster trading and more trade (evidenced with trading activity and liquidity), all would imply more market efficiency. Contrary to our expectations, however, market-wide and individual-level stock returns are still somewhat predictable; this is a clear violation of market efficiency.

Another expected improvement of SETS would be that the JSE would offer unique opportunities to investors with the wider investment opportunity set. This is mainly because of
the expectation that more local companies would list with the JSE due to lower trading costs (higher liquidity) and higher market participation. As expected, the JSE became more independent after the incorporation of SETS. It now offers better diversification opportunities for international investors.

References


