ABSTRACT
A key issue in market research is whether transparency, or the real time public dissemination of quotes and trades, improves market quality. Previous studies have focused solely on the American stock market. This paper uses Proc LP in SAS/OR to formulate a linear programming model to test the effects of transparency on the market quality in the Paris Bourse. A simplified model is used here to demonstrate the methodology. In this simplified model, two portfolios are constructed with a common attribute (number of trades). Based on a sample of 14 firms from October 1, 1993 to October 30, 1993, the LP model compares the transparency of portfolios using the bid-ask spread in French Francs. Within the model, the mean of the common attribute is held constant, while the difference in transparency is maximized.

INTRODUCTION
SAS/OR software is designed for creating and exploring models pertaining to operations research. Models can be created either for project management or for mathematical programming. Linear programming is included as an optimization technique that can be applied to distribution and resource allocation problems. Proc LP, the SAS system procedure for linear programming, can be applied to these and a variety of other problems such as those of market research, because it not only finds optimal solutions, but the procedure can also perform post-optimality processing analysis. These analyses include range, sensitivity, and parametric programming. This paper uses Proc LP to define the effects of market transparency on the market quality.

The debate over market transparency is a relatively new issue in financial research. Research to date has focused on American institutions, and has suggested a direct relationship between transparency and market quality. This paper develops the methodology to test this hypothesis on a foreign market, the Paris Bourse.

The research design itself involves the use of a linear programming (LP) model developed by Mclnish and Wood (1994a, 1994b). Using an LP model avoids many serious problems of research designs based on general linear models. Two stock portfolios are formed based on a common attribute that affect the market quality, but are as different as possible in the level of transparency. The sample consists of 14 firms and includes all transactions for these firms between October 1, 1993 and October 30, 1993.

Earlier studies have shown the effect of the trading frequency (number of trades) on spread (Mclnish and Wood (1994a)). Controlling trading frequency allows the value of the variables that measure the market quality to vary consistently across the two portfolios. The mean of the control variable is held approximately constant across the portfolios. Both the standard deviation and higher moments can also be controlled, but for the purposes of this paper, only the mean is held constant.

Degree of transparency is determined using the hidden volume (HIDDEN). This measure is preferred to hidden shares because investors think in volume rather than in percentage. In addition, earlier research that has focused on the proportion of hidden shares has failed to show a time pattern over the trading day.

It should be noted that Proc LP and linear programming models make no assumptions about multicollinearity; thus research by overcontrolling through the use of additional control variables is not jeopardized.

The model is run using SAS 6.09 with SunOS 5.4 on a Sun Microsystems Sparc 4. The methodology is being utilized by ongoing research by the Department of Finance, Fogelman School of Business at the University of Memphis in Memphis, Tennessee.

METHODOLOGY
Following McInish and Wood (1994a, 1994b), portfolios are formed with common attributes (control variables) and contrasting transparency. The LP model is solved over the entire sample. The attribute that is held constant across the two portfolios is denoted by:

\[
\text{TRADE} \quad \text{Number of trades over the time sample}
\]

In this paper, the time sample is for a month period. Market quality is denoted by the following variable:

\[
\text{SPREAD} \quad \text{Bid/Ask spread in French Francs}
\]

For each stock, the average of SPREAD is calculated over the time sample, and then, for each portfolio, the weighted average is determined with the weight solution as given by the LP model.

Following the lead of previous research, the formulation of the LP model is:

\[
\text{Max: } \sum_{j=1}^{14} \sum_{i=1}^{12} f_{i,j} \cdot \text{HIDDEN}_i,j
\]

where HIDDEN is the number of hidden trades for each firm, \( j \) is the firm, \( \Sigma \) is the sum across firms (over \( j \)), and \( f \) is the LP solution.

\[
\sum_{i=1}^{12} \sum_{j=1}^{14} \text{TRADE}_{i,j} = \sum_{i=1}^{12} \sum_{j=1}^{14} \text{HIDDEN}_{i,j} - \sum_{i=1}^{12} \sum_{j=1}^{14} \text{TRADE}_{i,j}
\]

where \( \text{TRADE} \) is the number of trades or the proxy for trading frequency and \( i \) is the portfolio.

\[
\Sigma_{i=1}^{12} \sum_{j=1}^{14} \text{TRADE}_{i,j} = \Sigma_{i=1}^{12} \sum_{j=1}^{14} f_{i,j} \cdot \text{HIDDEN}_{i,j}
\]

\( \Delta \) is the tolerance limit within which constraints are allowed to vary by ± 0.1.

\[
\sum_{i=1}^{12} \sum_{j=1}^{14} \text{HIDDEN}_{i,j} = \sum_{i=1}^{12} \sum_{j=1}^{14} f_{i,j} \cdot \text{HIDDEN}_{i,j}
\]
The objective function maximizes the difference in the hidden volume level between the two portfolios, while the first constraint holds constant the means of the portfolio attribute for the number of trades. The second constraint allows each portfolio to contain approximately the same number of firms, while the third constraint requires each firm to be included in at least one portfolio.

The inequality constraint allows the fluctuation of solution values into a ±0.1 range. If a strict equality is used, the LP model would force a firm to be in or out of a portfolio, precluding the possibility of a feasible solution. With an inequality, a firm may be spread over more than one portfolio. Mclnish and Wood (1993) have noted that since finance theory permits a continuous solution, it is realistic to own a stock spread over more than one portfolio. Since the LP model results in continuous solutions, the model is formulated as an assignment problem rather than as an integer problem. Therefore, a non-zero solution is held to between 0.9 and 1.1.

The SAS/OR Proc LP program follows:

```
l.p.sas -- spreading 14 stocks into 2 portfolios and maximizing the difference in the hidden volume across the portfolios while holding approximately constant the mean of attribute.
options ls=72 nocenter nodate nonumber noovp;
read in data set containing volume of hidden trades, number of shares executed, average (mean) trade over sample, and stock id.
-----
data start;
  infile 'stock.dat';
  input hidden trade mtrade stock;
  *-- standardize attribute;
  trade=trade/mtrade;
  *-- calculate sum of attribute;
  proc means noprint sum;
  var trade;
  output out=sums(drop=_type __
  sum=strade;
  *-- create matrix for lp model;
  data model;
  length jl $ 1 _type_ $ 8 _col_ _row_ $ 20
  _coef_ 8;
  *----------------------------------------------
  Set the mean, slack, sum and tolerance for the common attribute. Initialize _type_.
  *----------------------------------------------;
  retain attrib 'trade' slack 'slktra' trade strade/strade2; toler .1 _type_ ' , .
  keep _type_ _col_ _row_ _coef_ ;
  if _n_=1 then do;
    set sums;
  *----------------------------------------------
  In this section, the objective, lower, upper, and bound rows are defined.
  *----------------------------------------------;
  *-- objective function;
  _row_='diffhidd'; _type_='max'; output;
  *-- upper bound;
  _row_='upper'; _type_='upperbd'; output;
  *-- lower bound;
  _row_='lower'; _type_='lowerbd'; output;
  *-- define equality constraints;
  _type_='eq';
```

Now that the variables and constraints have been initialized, looping across portfolios and stocks begins...

--- portfolio and attribute assignments;
do j=1 to 2;
  Jl=j; _row_='pp'|jl; output;
  _row_=attrib|jl; output;
end;
end; **-- end of definitions;

--- loop across stocks;
do i=1 to 14;
  set start;
  _row_='pf'|stock_ _type_='eq'; output;
  _type_=' ';
  Create objective function and equality constraints.
  **-----------------------------------------------;
  *--- loop across portfolios;
do _~=1 to 2;
  Jl=J;
  *--- objective function for first portfolio;
  if j=1 then do;
    _col_=stock '|1';
    _row_='diffhidd';
    _coef_=hidden;
    output;
  end;
  *-- objective function for second portfolio;
  else if j=2 then do;
    _col=stock '2';
    _row_='diffhidd';
    _coef_=hidden;
    output;
  end;
  *-- hold equal attribute means across portf.;
  _row_=attrib|j1;
  _col_=stock 'j1';
  _coef_=strade; output;
  *-- right hand side of attribute constraint;
  if i=1 then do;
    *-- define attribute;
    _col_='rhs';
    _row_=attrib|j1;
    _coef_=strade2/output;
    *-- define slack;
    _row_=attrib|j1;
    _col=slack|j1;
    _coef_=1/output;
    *-- define upper bound of slack;
    _row_='upper';
    _col=slack|j1;
    _coef=(strade2/toler)/output;
    *-- define lower bound of slack;
    _row_='lower';
    _col=slack|j1;
    _coef=(strade2/toler)/output;
  end;
  *-----------------------------------------------
  Hold equal the number of stocks in each portfolio.
  **----------------------------------------------;
  ```
CONCLUSION

As we have seen, by utilizing the built-in flexibility and adaptability of SAS and SAS/OR, it is possible to create a linear programming model to test the effect of transparency on the market quality in the Paris Bourse. Through the use of a more complex version of this model, the results suggest, contrary to the American market, that a lesser degree of transparency enhances the quality of the Paris Bourse market.

REFERENCES


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