Insider trading and the likelihood of corporate insolvency: Evidence from UK firms

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Abstract

This paper investigates the relation between insider trading and the likelihood of insolvency. Using a unique dataset of 474 UK non-financial firms, of which 117 filed for insolvency between 2000 and 2010, we show that insider trading characteristics increase the predictive power of insolvency prediction models. The results indicate that although insider trading is generally associated with a lower likelihood of insolvency, the relationship is reversed during the six month period before firms file for insolvency. While the earlier trades seem to be motivated by superior information held by insiders, insider trading closer to the insolvency date is possibly initiated by signalling motives to influence market perception in an attempt to avert insolvency.

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1. Introduction

Corporate insolvencies[1] have serious consequences for the creditors as well as the owners of firms. The prediction of corporate failures and insolvencies has hence received a great deal of attention both in the academic literature and the financial press. In this paper, we aim to provide additional insights into our understanding of insolvency and managerial behaviour by investigating whether insider trading activities are related to the probability of insolvency. We carry out an empirical investigation using a unique dataset of 474 UK non-financial firms, of which 117 filed for insolvency during the period 2000–2010. We examine the differences across solvent and insolvent firms in relation to the trading activities of the board of directors and provide a logistic regression analysis to explore the relation between insider trading and the probability of insolvency. While the main focus of our paper is on the link between insider trading and the likelihood of insolvency, our analysis also controls for the effects of a number of accounting and market variables, as well as a rich set of corporate governance characteristics.

Prior studies in the literature provide strong evidence that insider trading is informative. It is shown that insiders possess superior knowledge about the firm's current valuation and its future performance. Insiders are also able to recognize changes in operating and financing characteristics more quickly than outside investors and analysts. Insider trading is recognized as an important source of information and less informed outsiders expect insider transactions to be informative. Consistent with this view, there is ample evidence in the current literature that insiders trade on superior inside information they hold and earn abnormal returns (Jiang and Zaman, 2010; Lakonishok and Lee, 2001; Seyhun, 1986). It is also shown that insiders trade on the basis of their contrarian beliefs, buying (selling) undervalued (overvalued) shares

in an attempt to take advantage of any perceived misvaluation (Jiang and Zaman, 2010; Piotroski and Roulstone, 2005).

Although the informative content of insider trading is acknowledged and supported empirically, the existing research on the role of insider trading and corporate insolvencies is limited. Specifically, prior studies focus on the abnormalities in insider trading patterns ahead of corporate bankruptcies. Furthermore, research is mostly limited to US companies. For instance, Gosnell et al. (1992) investigate two years of trade transactions using a dataset on both OTC and exchange listed US firms prior to corporate bankruptcy announcements during the period 1985–1987. They find that insiders increase the volume of sales before bankruptcies, although their findings hold only for unlisted companies in the sample. Their finding on publicly listed firms is in line with that of Loderer and Sheenhan (1989), who provide little evidence that insiders in firms filing for bankruptcy hold less stock than solvent ones. On the other hand, Seyhun and Bradley (1997) present evidence based on five years of trading prior to the bankruptcy announcement, using a larger sample of listed firms filing for bankruptcy between 1963 and 1992. They show that insiders sell their holdings prior to filing a bankruptcy petition and thereby avoid significant losses in their holdings of their firms prior to the bankruptcy. In a more recent study, Ma (2001) presents evidence that the volume of insider trading declines long before the bankruptcy announcement. However, it is shown that the drop is statistically significant only when companies are on the verge of bankruptcy, i.e. in the three months prior to the announcement.

In contrast to the prior research discussed above, which mainly examines the patterns of trading prior to the bankruptcy event, the primary focus of this paper is to examine the relevance of insider trading in determining the likelihood of bankruptcy. In this regard, we make two main predictions with regard to the motives of insiders to trade shares of their firms when in financial distress and/or prior to insolvency. Firstly, as discussed earlier, insiders are

generally better informed about the financial health and future prospects of their firms and hence are likely to trade on their superior information (or the market believes that they do). The evidence on the trading patterns of insiders before major price-relevant corporate events and announcements, including seasoned equity offerings (Karpoff and Lee, 1991), dividend initiations and/or cuts (Kose and Lang, 1991), stock repurchases (Lee et al., 1992), and mergers and acquisitions (Seyhun, 1990), supports this view. We predict that if corporate insiders trade on superior information of an imminent insolvency, they are more (less) likely to sell (purchase) stocks prior to insolvency and sale (purchase) transactions are associated positively (negatively) with the probability of insolvency. Furthermore, the predicted relationship is expected to be stronger in the period preceding the announcement.

Secondly, it is also possible that insiders may trade in an attempt to affect the firm's stock price and its value by influencing the market's perception of the firm's financial health. This is more likely to happen when the company is in financial distress and the probability of bankruptcy is significantly high. Insider trading can then be seen as a signalling opportunity to convey private information to the market. If insiders trade to impact the market's perception of their firm, contrary to the above prediction, they are expected to purchase shares in their firms prior to insolvency. We do not aim to explore if their signalling attempts are successful in avoiding insolvency. Instead, our objective is to explore whether insiders in insolvent firms have any signalling incentives when they trade before insolvency. We predict that the insiders are expected to increase (decrease) their purchase (sale) transactions before the insolvency. Accordingly, we expect a positive (negative) relationship between share purchases (sales) and the probability of bankruptcy. Similar to our first prediction, we also expect a stronger relation in the short term preceding the insolvency.

There is no clear-cut prediction regarding which of the above motives determines managerial trading behaviour before insolvency. Hence, whether corporate insiders purchase

or sell stocks when anticipating bankruptcy is mainly an empirical issue. In an attempt to shed some light on this question, we provide an analysis of the board of directors' trading activities for up to two years before the bankruptcy event. To do so, we consider three non-overlapping windows. Although the most relevant period for understanding the motives of insiders in trading is expected to be the last six months prior to the event of insolvency, we also examine trading information in the preceding six month and one year periods. This enables us to investigate the informative and signalling content of insider trading at different time horizons in determining the probability of insolvency. To examine the trading motives of insiders prior to insolvency, we consider the following proxies of insider trading: 1) net purchase, measured as the difference between aggregate purchases and sales in each window where a positive value indicates greater purchase than sale activities and *vice versa*; 2) number of transactions, given by the total number of purchases and sales made by insiders; and 3) the percentage of actively trading members on the board of directors. Additionally, we investigate the impact of sales and purchases separately. The dependent variable in our logistic regression analysis is dichotomous, taking the value of one if the firm goes bankrupt during the sample period and zero otherwise. In our investigation, we also control for several important corporate governance, accounting and market characteristics as potential determinants of the likelihood of going bankrupt.

Our baseline model includes similar accounting and market variables as those used in existing studies examining the determinants of financial distress and bankruptcy (see Altman and Narayanan, 1997; Charitou et al., 2004; Shumway, 2001 among others). It is shown in this strand of the literature that leverage, firm size, stock returns and their volatility are the main factors that impact on the probability of bankruptcy. For robustness purposes, we also provide regression results by incorporating the KZ Index (Baker et al., 2003) instead of accounting and market characteristics.

In addition, following studies exploring the impact of corporate governance mechanisms on the probability of bankruptcy, we consider four governance measures, namely board size and independence, managerial and institutional ownership. In doing so, we acknowledge the potential role of corporate governance in reducing the agency problems within corporations and hence the probability of bankruptcy (Lajili and Zéghal, 2010; Platt and Platt, 2012; Sudarsanam et al., 2011). In particular, our main argument is that in firms with poor corporate governance, the costs associated with asymmetric information and agency problems are expected to be more severe, limiting the ability of these firms to access external finance. Moreover, when they raise finance externally the cost is significantly higher. It is then reasonable to predict that the probability of insolvency is higher in firms with poor corporate governance practices.

The main finding of our analysis is that insider trading increases the predictive power of insolvency models. There is strong evidence that in the period leading to insolvency insiders in insolvent firms increase their purchase transactions significantly. Moreover, in line with prior research, we observe different intensity of trading in insolvent and solvent firms. In the more distant past, the trading volume and the percentage of trading directors in insolvent firms are significantly lower than in solvent firms, whereas the activity of insiders rises significantly when companies are on the verge of insolvency.

In line with the signalling prediction, it is found that there is a positive relation between net purchase and the probability of insolvency only in the period before insolvency. In more distant periods, the relation becomes negative, which is more aligned with the superior information view. The findings also show that increases in both the volume of trade and the number of trading directors in the period leading to insolvency are associated with a greater probability of insolvency. On the other hand, a higher number of active insiders and volume of trade in earlier periods lower the likelihood. Overall, our analysis suggests that even

though insider trading is generally driven by information held by insiders, the main motivation to trade in insolvent firms near bankruptcy seems to be to signal to outsiders in an attempt to change the market's perception of the firm's financial health.

Our contribution in this study is twofold. First, to our knowledge, this is the first attempt in the literature to explore the association between insider trading and the probability of bankruptcy. Although prior research provides evidence on the patterns of insider trading prior to bankruptcy, there has been no attempt to directly examine the relationship between insider trading and the probability of insolvency. By examining this relationship, this study not only provides further insights into our understanding bankruptcy prediction models, but also extends the literature on the informative content of insider trading. It is also worth mentioning that our approach in doing so is distinct from earlier studies. We do not argue in the paper that insider trading impacts on the probability of insolvency *per se*. Instead, we conjecture that certain insider trading characteristics may be associated with the state of imminent insolvency and incorporating them in bankruptcy prediction models can enhance the predictive power of these models. Furthermore, we do not test the informative content of insider trading – for future returns as generally done in the literature - using an event study methodology. Our approach is rather to examine the informativeness of insider trading for insolvencies by focusing on the link between pre-insolvency insider trading and the event of insolvency.

Secondly, our study contributes to efforts to understand the interaction between corporate governance characteristics and corporate insolvencies. We note that prior research investigating the role of corporate governance in determining the probability of bankruptcy is dominated by studies carried out for US firms (Daily and Dalton, 1994a, b; Fitch and Slezak, 2008; Gilson, 1990; Kose and Lang, 1991; Platt and Platt, 2012). Although the corporate governance characteristics in the UK and the US are said to be generally similar, there are

also important differences between the two countries concerning the ways in which the corporate governance system functions in relation to monitoring and disciplining the management of firms. In line with the existing research on corporate governance and insolvency, we find that board independence diminishes the probability of insolvency. Nevertheless, our analysis reveals several other interesting results. First, board size has a negative effect on the probability of insolvency, which is not consistent with the classic view that small boards lead to better overall firm performance. Second, in contrast to the results on US companies, the impact of institutional ownership on insolvency is found to be positive. We argue that these findings to some extent arise from the differences in the US and the UK corporate governance systems, possibly providing further evidence that institutional investors in the UK are not effective in monitoring firms' management and hence reducing the agency conflicts between managers and shareholders.

The remainder of the paper is organized as follows. Sections 2 and 3 describe the methodology and data used in the study respectively. Section 4 presents the results of univariate and multivariate analyses. Finally, Section 5 concludes the paper.

2. Methodology

We model the probability of insolvency using a logistic regression where the dependent variable is binary, taking the value of 1 if the firm goes insolvent and 0 otherwise. We estimate the following model to predict the likelihood of insolvency

$$\Pr(y=1|x)=G(\beta_0+\beta_1 x_1+...+\beta_k x_k) \quad (1)$$

where $P(x)$ is the probability of the insolvency outcome occurring (i.e. the outcome y=1) given the vector of explanatory variables x_i . Although statistically significant logit coefficients of the independent variables indicate that they have a significant influence on the predicted probability of insolvency, their economic interpretation is not as straightforward as,

for instance, for OLS beta coefficients. While OLS beta coefficients show the effect of a marginal change in explanatory variables on a dependent variable, logit beta coefficients are expressed in terms of log-odds units, specified by

$$\Pr(y=1|x)=e^{(\beta_0+\beta_1x_1+\ldots+\beta_kx_k)}/(1+e^{(\beta_0+\beta_1x_1+\ldots+\beta_kx_k)}) \quad (2)$$

The signs of estimated coefficients indicate whether higher values of independent variables lead to a lower or higher likelihood of a y=1 outcome. To assess how different values of x influence the likelihood of insolvency, one can use either odds ratios or fitted probabilities. The odds ratio shows how the odds of a y=1 outcome (i.e. insolvency) changes between two values of an explanatory variable. However, given that the odds ratio requires a benchmark value of an independent variable, it would not be helpful to estimate predicted values of a y=1outcome for a given value of x. Instead, the preferred method is first to substitute in the estimated logit model the desired values of explanatory variables to calculate logit odds value for the model. It is then, by substituting this value in Equation 2, to derive the probability of insolvency for a specific value of an explanatory variable while holding all other independent variables at their mean values.

Although this analysis can be carried out for all of the explanatory variables in our specification, we restrict our attention to insider trading characteristics. Specifically, we provide a sensitivity analysis for the probability of insolvency by evaluating it at various values of net purchase, number of trades, and the ratio of active insiders at different time horizons. Furthermore, to control for endogeneity, we measure explanatory variables with at least a one year lag. However, it should be noted that the length of lags differs slightly across firms in the sample as the insolvency dates are observed randomly compared to financial reporting dates which are more standardized. In addition to insider trading characteristics, apart from the firm-specific characteristics, we also control in all estimations for time-specific and industry-wide effects by including year and industry dummies respectively.

3. Data

This study is based on a unique set of data, which combines information from three different sources. We started by identifying the non-financial UK firms that went insolvent over the period 2000–2010. For this purpose, we used the current activity status of companies posted on the Companies House website. We classified a firm as insolvent by using a binary variable with 1 representing its status as one of the following insolvency procedures: administration, liquidation, receivership, or voluntary administration; and 0 otherwise. During this process, we identified 234 firms that had entered insolvency procedures. In addition to the registration numbers of firms, their full name and status, the Companies House website also contains the dates of the accounts last produced and the dates of filing for insolvency. Based on these dates, we observed that there are firms that stop producing financial statements well before entering insolvency procedures. As there is a large amount of specific information, essential for our analysis, which is available only in financial reports, we restricted our sample to only those companies for which the gap between the last financial statements with fully available information and the date of entering insolvency does not exceed three years.

Subsequently, using the names of selected companies we manually identified the corresponding International Securities Identification Numbers (ISINs), which we use to merge the accounting and market data from DataStream and the corporate governance and insider trading information obtained from Morningstar UK. As a result of these procedures, we lost half of the firms in our initial sample, ending up with 117 insolvent companies with the complete set of information essential to our analysis.

The insider trading data obtained from Morningstar UK includes information on the transactions of individual insiders, including members of board of directors, company officers and other major shareholders. Additionally, we obtained from the same source the

announcement dates of the insider transactions and their types. For our analysis, we selected open market purchases and sales performed by only executive and non-executive directors during the sample period. Further we aggregated the characteristics of multiple transactions for the chosen windows of time.

To examine the likelihood of insolvency, we compare the insolvent companies with those in the control sample, created using the following procedure. Each of the insolvent firms identified with complete data available was matched as closely as possible with a solvent company based on the period of the insolvency filing and the industry code. Insider trading information for solvent firms was collected for periods marked by the three windows established for the corresponding insolvent firm. Consequently, for our analysis we generated a sample of 474 firms of which 117 were insolvent.

Table 1 presents the composition of the sample dataset. Specifically, Panel A of the table shows separately the number of insolvent and control firms over the investigation period. The highest number of firms across the sample period is observed as 68 in 2003, 23 of which are insolvent. On the other hand, there are only 14 observations in 2005, with eight solvent and six insolvent firms. It is also worth mentioning that there are only three insolvent firms included in the sample in 2009, while the total number of firms is 25 in the same year. Panel B presents the distribution of firms across the industries classified on the basis of ICB industry codes. The distribution is generally well balanced with the exception of the technology sector, represented by only 13 (five solvent and eight insolvent) firms in the sample.

[Insert Table 1 here]

4. Empirical results

4.1. Summary statistics and univariate analysis

The definitions of the variables used in the study are presented in Table 2 and Table 3 provides descriptive statistics for the variables used in the study.

[Insert Table 2 here]

[Insert Table 3 here]

In Table 3, we report the mean values and their standard deviations for the whole sample and separately for the solvent and insolvent firms. Furthermore, the mean difference t-test results for each variable are reported, where the null hypothesis is that the mean values of the variables across the solvent (control) and insolvent groups are equal. We present our findings by grouping the variables in four categories: corporate governance, accounting, market and trading characteristics.

Starting with the discussion of the descriptive statistics of the corporate governance characteristics used in the study, the results reveal significant differences between solvent and insolvent firms with respect to board size, independence and institutional ownership. In line with Darrat et al. (2010) and Platt and Platt (2012), we find that the companies that filed for insolvency have on average smaller boards, with just under six members, compared to approximately seven directors sitting on the average control firm's board. We also find that the composition of the board across the two samples is significantly different. Specifically, the non-executive directors of insolvent firms constitute on average about 47 per cent of the board, compared with more than 52 per cent in solvent firms. The results suggest that the boards of solvent firms in our sample tend to be more independent than insolvent firms. Despite the differences in the total number of directors represented on the board, the equity ownership of board members is almost the same in both solvent and insolvent samples. The percentage shareholding of trading directors is approximately 13 per cent in both groups.

Finally, we find that the average institutional ownership in the insolvent sample of firms is significantly higher than that for the control firms, approximately 30 per cent and 20 per cent respectively.

There are also significant differences between the two samples regarding the accounting variables used in the analysis. Not surprisingly, the mean leverage ratio for insolvent firms is significantly higher, approximately 28 per cent, than for the firms in the control group, about 16 per cent. That is, the debt ratio of insolvent firms is 77 per cent higher than the leverage ratio of solvent firms in the sample. In line with this finding, the results show that the average KZ Index for insolvent firms is significantly higher at about 2.33, compared to an average score of -0.05 for the firms in the control group. This is not surprising and is also in line with the view that firms with a higher KZ Index are likely to be more constrained than those with lower scores in relation to their ability to raise external finance. Finally, compared to the firms in the control group, insolvent firms are significantly smaller and a smaller percentage of them pay out dividends to shareholders during the sample period. As for the market variables, the stock return of insolvent firms prior to the event of insolvency is negative, approximately -32 per cent, and significantly lower than the average return on the solvent firms' stocks, which is just under 10 per cent for the sample period. The volatility of past returns is expectedly higher for insolvent firms. Overall, the comparison of the relevant accounting and market variables indicates that the insolvent firms used in the analysis exhibit greater risk and a greater degree of financial constraint and this seems to be perceived by the market correctly, reflected in lower returns and greater stock return volatility.

Turning to the results on insider trading measures, we find significant differences between the two samples with regard to the mean values of the size of net purchase, the number of transactions and board activity before the insolvency event. We measure the activity of insiders over three consecutive non-overlapping trading windows over 24 months prior to the

insolvency date, namely 6 months, 6 to 12 months, and 12 to 24 months periods. The last period ends at the last insider transaction prior to the insolvency date. The mean comparison test indicates significant differences between the two samples in the majority of measures, with the exception of the trading volume measure for the period 12–24 months prior to insolvency and the number of trades within the closest six months. The results indicate that in firms filing for insolvency, insider trading activity diminishes during the more distant period (i.e. 6-24 months) in comparison to healthy firms. For example, on average in the period from 24 to 12 months prior to the insolvency we observed 4.265 trades in insolvent firms performed by 32.1 per cent of the board, whereas in the same period in the solvent firms we observed a mean of 9.986 transactions performed by 44.5 per cent of the board. This is in line with the findings of Ryan (2005), who reports that in situations of increased interest from analysts, insider trading volume decreases. However, in the last six months the situation reverses in that for firms facing insolvency we observe a greater frequency of trading with an average of 5.56 transactions carried out by 51.3 per cent of the board, in comparison to an average of 4.96 trades performed by 25.1 per cent of directors in the control sample. Additionally, in the short-term period we observe a significant difference between net purchases across the two groups. The net purchase in insolvent firms equals 2.9 per cent of market value in comparison to -0.4 per cent in solvent firms; this is in contrast to the findings of Seyhun and Bradley (1997), who find that insiders mostly sell their stocks prior to insolvency. Our initial finding seems to be in line with the view that insiders may attempt to signal better prospects to the market by purchasing shares in their firms.

4.2. Multivariate logit analysis

This section investigates whether the likelihood of insolvency is related to insider trading activity in addition to the control variables outlined in the Introduction. In Table 4 we present

the results of four different logit specifications. Model 1 is our baseline model, estimating the likelihood of insolvency as a function of accounting, market and corporate governance only as control variables. In Models 2 to 4 we incorporate in the empirical analysis the trading characteristics of directors. By comparing models with and without the main variables of interest, we show that the inclusion of the insider trading measures increases the power of bankruptcy prediction models, evidenced by the increases in the log-likelihood value and pseudo R^2.

4.2.1. Corporate governance, accounting and market variables and the likelihood of insolvency

Starting with Model 1, we find that the majority of the estimated coefficients are significant and generally in line with the predictions as to their impact on the likelihood of insolvency. Specifically, the findings for the corporate governance characteristics suggest that firms with larger and more independent boards are less likely to be insolvent. The negative and significantly estimated coefficient of board size is not consistent with the traditional view (see e.g. Yermack, 1996) that small boards are more efficient and better organized than larger boards, which should lead to better firm performance and hence a lower probability of insolvency. Instead, firms with larger boards are less likely to be insolvent, supporting the evidence provided by Platt and Platt (2012) that larger boards provide firms with more business contacts, which in turn enables them to avoid insolvency. However, as also discussed in Darrat et al. (2010), it should be noted that the negative finding can be driven by the fact that financially distressed – in particular near-insolvent – firms lose directors prior to the insolvency, leaving firms with smaller boards.

We find that the likelihood of insolvency decreases with board independence. This is consistent with the findings of prior research showing that the market reacts more positively to decisions taken by outsider-dominated firms (Borokhovich et al., 1996) and more

independent boards are likely to be better monitors (Shleifer and Vishny, 1997) leading to lower agency costs. To the extent that boards with greater non-executive director representation are more likely to make better decisions and act in shareholders' interests, greater board independence should lead to better performance, lower cost of capital and hence a lower probability of financial distress in the first place. Furthermore, financially distressed firms should have a better chance of survival as the access of independent boards to external finance should be easier, which is essential to avoid bankruptcy.

As for the impact of equity ownership variables, we do not find a significant relation between board ownership and the likelihood of insolvency, while the negative sign is consistent with our predictions. This finding does not support the view that board ownership is expected to align the interests of managers and owners and therefore to reduce the costs of agency problems within corporations (Jensen and Meckling, 1976). However, the relation between institutional ownership and the likelihood of insolvency is positive and highly significant. This provides further support for the argument that financial institutions, despite their large ownership position, do not take an active role in corporate governance in the UK, adopt a passive stance towards monitoring and disciplining firms' management, and hence have little influence on managers (Franks et al., 2001). This would in turn lead to higher expected agency costs within the firm, raising the cost of finance and lowering firm value, eventually increasing the probability of insolvency.

Finally, the results in relation to the remaining non-trading control variables are generally consistent with our predictions. Specifically, the relation between leverage and the likelihood of insolvency is positive and significant, while the impact of dividends is significantly negative, although only at the 10 per cent level. To the extent that higher levels of leverage increase the probability of financial distress, the positive influence of leverage on this likelihood is not surprising. We further explore this issue in Table 5 when we replace the

variables that are related to the probability of bankruptcy with the more general KZ Index. The negative relation between dividend policy and the probability of insolvency, albeit rather weak, may arise because the firm's dividend policy can indicate its flexibility to resort to internal resources when needed and be seen as an inverse proxy for the degree of financial constraint. Dividend paying firms are also expected to be more profitable, which would also lower the probability of insolvency. Also, in line with this, we find that past stock returns exert a negative effect in the likelihood of insolvency. That is, firms with lower stock returns are more likely to go bankrupt. The estimated coefficient is highly significant at the 1 per cent level. In addition, the volatility of stock returns is positively related to the likelihood of insolvency. Expectedly, firms with more volatile market returns are more likely to find themselves in financial distress and ultimately in insolvency. However, we note that the higher stock return volatility, observed prior to the insolvency, may be due to the financial distress of the firms before officially filing for insolvency. We do not investigate this issue further as we do not examine financial distress separately from insolvency. One result that is inconsistent with expectations relates to firm size. Although the sign of the estimated coefficient of firm size is expectedly negative, suggesting a lower probability of insolvency for larger firms, the relation is not statistically significant. Overall, our findings in relation to the control variables from the baseline model hold throughout the alternative specifications and hence we do not discuss them again in the rest of the paper.

4.2.2. Trading activity and the likelihood of insolvency

As explained earlier, we use three different trading activity variables in estimating the relation between insider trading and the likelihood of insolvency. Moreover, each trading activity proxy is measured over three different windows to test if managerial incentives and motives to trade change depending on the length of time before the insolvency event. The closest time horizon we consider in this respect is the last six months prior to insolvency (6–

12m) and the furthest (12–24m) starts 12 months before the insolvency date and goes back a further 12 months from that date. In Model 2 we examine the impact of net purchase, which is defined as the ratio of the difference between the sum of purchases and sales made by board members to the market capitalization of the firm. The results reveal that the relation between net purchase and the likelihood of insolvency is significant only in the last six months of trading. The estimated coefficient is positive and significant, albeit at the 10 per cent level. Strictly speaking, this result implies that firms in which insiders make relatively more purchase than sale transactions in the period leading to insolvency are more likely to go insolvent. However, the positive relation possibly suggests that purchases made by directors may be driven by their attempt to change the market's perception of the firm rather than to make profit using superior information. If the latter held, the estimated relation would be negative or at least insignificant. The relationship between net purchase in the two remaining windows and the likelihood of insolvency is not statistically significant.

[Insert Table 4 here]

In Model 3 we examine the relation between the likelihood of insolvency and the total number of open market purchases and sales performed by insiders without distinguishing between different types of transaction. We do so to test if the volume of trade, used as a proxy for trading activity, can be used to predict insolvency. The estimated coefficient of this variable in the first window (0–6m) is positive and significant at the 1 per cent level. Although the descriptive statistics presented earlier suggest that the number of insider transactions is generally lower in insolvent firms, the volume increases significantly in the last six months prior to insolvency compared to the penultimate six months (6–12m). While the mean volume more than doubles for the insolvent firms in the sample between the two windows, it is stable for the solvent control firms. Given that the observed increases are mainly due to open market purchases rather than sales, the positively estimated relation

between the number of insider transactions and the likelihood of insolvency provides further support for the suggestion that insiders become significantly more active in the months prior to insolvency, possibly in an attempt to affect the market's perception of the firm. However, this does not seem to be the case during the earlier windows. The impact of the number of trades becomes negative and significant, suggesting that more distant insider transactions have an opposite impact on the probability of insolvency, i.e. the higher the number of insider trades and hence the more active they are, the lower the probability of insolvency. This is what one would normally expect given that insiders are likely to be more cautious and diligent when trading ahead of adverse events such as insolvency.

In Model 4 we investigate the relation between the activity of the board, measured by the ratio of the number of trading directors to board size and the likelihood of entering insolvency. The results are very similar to those we report above with respect to the impact of the number of transactions on insolvency. Specifically, we find that while insider activity exerts a negative influence on the probability of insolvency in the last six-month period (0–6m), the relation is reversed during the earlier two windows.

4.2.3. KZ Index and the probability of insolvency

In Table 5 we replace the market and accounting variables with the KZ Index, normally used in previous research as a proxy for the probability of financial distress and financial constraint (Almeida et al., 2004; Baker et al., 2003)[2]. Consistent with expectations, the relation between the KZ Index and the likelihood of bankruptcy is positive throughout all specifications. The influence of insider trading variables remains similar, indicating that when close to insolvency, directors in insolvent firms are more active in terms of their trading than in solvent firms. Additionally, in line with the findings presented in Table 4, insider trading during the last six months influences positively and significantly the likelihood of insolvency, whereas in earlier periods it has a negative impact.

[Insert Table 5 here]

4.3. Sensitivity analysis: insider trading and the probability of insolvency

As discussed earlier, the reported coefficients in Tables 4 and 5 are not helpful to evaluate the marginal impacts of the changes in the variables of interest on the probability of insolvency. In Figures 1 to 3, we provide a sensitivity analysis by evaluating the predicted probabilities of insolvency against insider trading. In all of the figures, we plot the probabilities using the results reported in Table 4. For example, in estimating and plotting the probability of insolvency at different levels of net purchase in Figure 1, we use the estimated results for Model 2. We evaluate the rest of the independent variables at their mean values.[3]

Overall, the plots suggest that the probability of insolvency is generally more sensitive to changes in insider trading measures in the last window (0–6m) regardless of the trading variable used in estimating the probabilities. Furthermore, the upward and downward sloping curves plotted in Figures 1–3 are expectedly in line with the estimated coefficients regarding each aspect of insider trading. Figure 1 shows that the sensitivity of the probability of insolvency, given by the slope, increases significantly in the 0–6 month period as the value of net purchases increases. For example, the probability increases from about 10 per cent to around 23 per cent as the value of net purchases ranges from -0.05 per cent, which implies greater sales than purchases made by insiders, to 0.05 per cent. However, the probability of insolvency is much less sensitive to changes in net purchases in the earlier windows. While the estimated probability curve is still upward sloping in the earlier 6–12 month window, the change in the probability of insolvency when net purchases increase from -0.05 per cent to 0.05 per cent corresponds to only about a one percentage point increase. The sensitivity is higher and the slope is now negatively sloped in the last window but the change in the probability for the same range in the last window is still less than three percentage points.

[Insert Figures 1, 2 and 3 here]

Figures 2 and 3 provide a similar analysis for the number of transactions and active insiders respectively. The results are more clear-cut compared to those reported for the net purchase variable. However, it is still the case that the sensitivity of the probability of insolvency is much stronger in the first window closer to the event of insolvency. As Figure 2 shows, the probability of insolvency increases from about 10 per cent to nearly 90 per cent as insiders in a typical firm increase the number of their trades from 0 to 50 times within the six months preceding the firm's insolvency. However, the change in the slope of the probability curve in the earlier windows suggests that the likelihood of insolvency decreases with increases in the number of trades. Furthermore, the economic magnitude of the changes and hence the sensitivity is smaller, while the estimated probability of insolvency approaches zero relatively quickly as the period in which the trade takes place gets further away. Finally, the probability of insolvency increases from about 10 to over 60 per cent as the ratio of directors engaged in trading changes from 0 to 100 per cent. On the contrary, in the earlier windows an increase in the ratio of active traders decreases the probability of insolvency and at a much lower magnitude. As the ratio increases from 0 to 100 per cent, the probability of insolvency decreases from about 18 per cent to less than 10 per cent in the 6–12 month window and to less than 5 per cent in the 12–24 month window.

The sensitivity analysis provided in this section clearly shows that the most relevant insider activities regarding the likelihood of insolvency take place in the last six months preceding the insolvency. In addition to the evidence presented earlier with respect to the statistical significance of the estimated coefficients of insider trading variables, the sensitivity results indicate that the economic impact of insider trading on the probability of insolvency during the last period differs significantly from that in the earlier periods in terms of both the sign and magnitude. The results seem to support our earlier conclusion that the motives of insiders in trading are different during the ultimate window of trading and the earlier ones.

While it is beyond the scope of this paper to test if this is the case, the results indicate that the informative content of insider trading and the incentives of insiders to trade depend on how close insiders think they are to insolvency. It seems that increased trading activity preceding the insolvency does not help firms avoid insolvency.

4.4. Additional Tests

To ensure the robustness of our results, we carried out a series of robustness checks. The results are reported in Table 6. For brevity, we only report the findings of the insider trading variables. The results for the rest of the variables remain qualitatively very similar.

4.4.1. Type of transaction: purchases vs. sales

We first examine if the positive relation between net purchase and the likelihood of insolvency is mainly caused by transaction type. To do so, instead of using the net purchase measure, in Model 1 we incorporate purchase and sale transactions made separately during each period. The findings indicate that the positive relation between the transactions in the last period and the likelihood of insolvency is driven by purchase transactions. Specifically, the estimated coefficient of purchases made in the 0–6 month window remains positive and becomes significant at the 1 per cent level. The coefficients for the remaining windows are still negative but, contrary to what we report in Table 4, they are now significant. In contrast, we do not find any significant relation between sales transactions and the insolvency likelihood in any of the windows. Additionally, the findings for the control variables including the corporate governance proxies remain similar.

We next perform a similar exercise in Model 2 by distinguishing between the number of sale and purchase transactions in estimating the relation between the number of transactions and the likelihood of insolvency. We find that the number of sale transactions made by directors exerts very little influence on the likelihood of insolvency. The estimated

coefficients are not significant in the first two windows, whilst the coefficient in the last window is negative and significant at the 5 per cent level. The findings on the number of purchases, however, reveal a much more significant relationship between purchases and the likelihood of insolvency. They are also in line with our earlier interpretation of the results with regard to the net purchase variable (in Model 2 of Table 4) and the size of purchases variable (in Model 1 of Table 6). That is, the results suggest that in the period preceding the insolvency insiders in insolvent firms possibly increase their purchase transactions in an attempt to influence the market's perception of the firm and avoid insolvency.

[Insert Table 6 here]

We take this finding as further evidence for the signalling prediction. On the other hand, the coefficients estimated for more distant periods possibly point to different reasons why there is a significant relationship between director purchase transactions and the probability of insolvency. It seems that directors purchase shares in earlier periods on the basis of information that is relevant to firm value and/or the probability of insolvency. While we do not test if the purchases made in these windows are associated with abnormal returns in the short and/or long term, we show that they are associated with a lower probability of insolvency. Furthermore, the existing literature on the informative content of insider trading provides strong evidence for the significant impact of purchase transactions in explaining the positive abnormal returns observed in the subsequent periods.

Taken together, these results suggest that when directors purchase shares, the motivation is possibly to profit from privately held superior information. However, the main motivation to purchase when the insolvency threat is real seems to mimic the solvent firms.

4.4.2. Type of director: executive vs. non-executive

As a final robustness test in Table 6, we consider the possibility that the relation between the percentages of directors engaged in trading and insolvency changes depending on whether

the trading insider is an executive or a non-executive director. In Model 3, we include the percentage of executive and non-executive trading directors separately and find that the results are very similar in terms of the sign and significance of the estimated coefficients. It seems that what matters most is the total number of trading directors. Similar to the findings for other insider trading characteristics, we find an asymmetry with respect to the impact of the percentage of active traders on the likelihood of insolvency across different windows. The positive (negative) impact of the number of both executive and non-executive directors on the likelihood in the last (earliest) period provides further support for the signalling (superior information) view.

We recognise that the impact of types of transaction (i.e. sales and purchases) may also vary with the types of directors who trade. To address this possibility we run a number of regressions by further classifying each type of transaction into two groups identified by director type. The results are very similar to our earlier findings and hence are not reported separately. Specifically, the impact of sale transactions is insignificant regardless of director type and the significant impact of purchases remains unchanged.

5. Concluding remarks

This paper provides an empirical investigation on the determinants of the probability of insolvency using a unique dataset from the UK companies. The main objective is to examine if insider transactions performed by executive and non-executive directors during the period before insolvencies are informative in predicting the probability of insolvency. In this regard, we test two competing predictions. On the one hand, the superior information prediction suggests that directors of insolvent firms trade on their superior information and tend to sell stocks prior to insolvency. On the other hand, the signalling prediction implies that insider trading, especially in the period preceding insolvency, is driven by the insiders' incentives to

affect the market's perception of the firm's financial health. Consistent with the latter, our analysis provides evidence that in the period leading to insolvency insiders in insolvent firms increase their purchase transactions significantly. We provide further evidence for the signalling prediction that the relationship between net purchase and the probability of insolvency is positive only in the six-month period before the insolvency. In more distant periods we observe a negative relation, which is more aligned with the superior information view proposed in the paper.

We also find that board size and independence, and the equity ownership of institutional investors are significant corporate governance characteristics in determining the probability of insolvency. Interestingly, the negative impact of board size and the positive influence of institutional ownership on insolvency are not consistent with what previous corporate governance and bankruptcy prediction studies show. We argue that the differences in the interplay between these firm-specific governance features and the likelihood of insolvency are due to the specific characteristics of the corporate governance system in the UK.

Overall, the findings of our study point to the importance of insider trading characteristics in determining the probability of insolvency. An avenue for future research is to distinguish between different directors by focusing on the potential differences regarding the incentives of, for example, firms' CEOs and CFOs. It is also important to incorporate country-specific information in the analysis with regard to insider trading and corporate governance characteristics to provide more insights into the bankruptcy prediction models. We note that the finding in support of the signalling prediction found in the paper arises from the increasing efforts of insiders in insolvent firms to influence the market's perception during the period preceding the insolvency. Nevertheless, we do not test if these attempts are successful for some firms in avoiding bankruptcy. This awaits future research.

Notes

1. Corporate bankruptcy is referred to as insolvency in the United Kingdom. We use these terms interchangeably in the paper.
2. The KZ index is a measure of financial constraint, widely used in the literature to show the level of difficulty which companies are expected to face in raising external finance. It is estimated using the following equation (as also described in Baker et al., 2003):

$$-1.002 \text{ x } \frac{\text{Cash Flow}_{it}}{A_{i,t-1}} + 0.283 \text{ x } Q_{it} + 3.139 \text{ x Leverage}_{it} - 39.368 \text{ x } \frac{\text{Dividends}_{it}}{A_{i,t-1}} - 1.315 \text{ x } \frac{\text{Cash Holdings}_{it}}{A_{i,t-1}}$$

where *A* is the book value of total assets, *Cash Flow* is defined as the sum of EBIT and Depreciation; *Q* is the market value of equity plus assets minus the book value of equity; *Leverage* is the sum of long-term and short-term debt over common equity; *Dividends* are the cash dividends paid; *Cash Holdings* are cash balances.

3. A similar analysis is carried out using the results in Table 5 and also by using the median values of the remaining independent variables. The results are very similar to those obtained using the logit results in Table 4 and hence are not reported separately for brevity. The results are available from the authors upon request.

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TABLES AND FIGURES

Table 1

The composition of the sample of solvent and insolvent firms

A. Number of firms by year

Year	Solvent firm	Insolvent firm	Total sample
2000	28	14	42
2001	30	11	41
2002	49	14	63
2003	45	23	68
2004	24	7	31
2005	8	6	14
2006	39	9	48
2007	42	11	53
2008	37	11	48
2009	22	3	25
2010	33	8	41
Total	**357**	**117**	**474**

B. Number of firms by industry[a]

ICB name	ICB code	Solvent firm	Insolvent firm	Total sample
Basic Materials	1000	28	6	34
Consumer Goods	2000	89	33	122
Consumer Service	3000	63	19	82
Health Care	4000	38	7	45
Industrials	5000	86	29	115
Technology	6000	5	8	13
Telecommunication	9000	48	15	63
Total		**357**	**117**	**474**

This table presents the distribution of solvent (control) and insolvent firms over the sample period 2000-2010 in Panel A and across industries in Panel B. The Industry Classifying Benchmark (ICB) is used in classifying firms into seven industry groups.
[a]Classification in accordance with ICB codes.

Table 2

Definitions of variables

Variable name	Definition
Insolvency dummy	Dummy variable that is equal to one if a company enters insolvency procedures and zero otherwise.
Accounting	
Size	Natural logarithm of total assets.
Leverage	The ratio of total debt to total assets.
Dividend	Dummy variable that is equal to one if a company pays dividends to its shareholders and zero otherwise.
KZ Index	A measure of financial constraint, estimated using the following equation as described in Baker et al. (2003): $-1.002 \times \frac{\text{cash flow}_{it}}{A_{i,t-1}} + 0.283 \times Q_{it} + 3.139 \times \text{leverage}_{it} - 39.368 \times \frac{\text{dividends}_{it}}{A_{i,t-1}} - 1.315 \times \frac{\text{cash holdings}_{it}}{A_{i,t-1}}$ where *A* is the book value of total assets, *Cash Flow* is defined as the sum of EBIT and Depreciation; *Q* is the market value of equity plus the book value of total assets minus the book value of equity divided by the book value of total assets; *leverage* is the ratio of the sum total debt to total assets; *dividends* are the cash dividends paid; *cash holdings* are cash balances.
Market	
Stock return	Aggregated monthly firm's returns minus the aggregated value-weighted monthly FTSE all-share index return in the same year.
Return volatility	Standard deviation of the regression of monthly stock returns in a year on the value-weighted FTSE all-share index for the same year.
Corporate governance	
Board size	Total number of directors on the board.
Board independence	The ratio of non-executive directors to board size.
Board ownership	The percentage holding of executive and non-executive directors.
Institutional portfolio	Average institutional portfolio percentage.
Insider trading	
Net purchase	The value of net purchases (purchases–sales) made by insiders over market capitalization in:
	0–6 m six-month period prior to insolvency
	6–12 m two- to one-year period prior to insolvency
	12–24m two- to one-year period prior to insolvency
No. of trades	Total number of purchases and sales made by insiders in:
	0–6 m six-month period prior to insolvency
	6–12 m two- to one-year period prior to insolvency
	12–24m two- to one-year period prior to insolvency
Active insiders	The ratio of number of trading directors (who make open market purchases or sales) to board size in:
	0–6 m six-month period prior to insolvency
	6–12 m two- to one-year period prior to insolvency
	12–24m two- to one-year period prior to insolvency

This table gives the definitions of the variables used in the analysis. The definitions are grouped in four categories, namely accounting, market, corporate governance and insider trading variables.

Table 3

Descriptive statistics and mean comparisons between insolvent and solvent firms

	Full sample			Insolvent firms	Solvent firms	
	N	Mean	Std. dev.	Mean	Mean	t-test
Corporate governance characteristics						
Board size	474	6.538	2.157	*5.701*	*6.812*	4.957 ***
Board independence	474	0.508	0.157	*0.466*	*0.522*	3.386 ***
Board ownership	474	0.132	0.172	*0.131*	*0.132*	0.011
Institutional portfolio	474	0.231	0.300	*0.306*	*0.207*	-3.140 ***
Accounting ratios						
Size	474	17.894	1.901	*17.213*	*18.117*	4.559 ***
Leverage	474	0.187	0.196	*0.279*	*0.157*	-6.083 ***
Dividend	474	0.593	0.492	*0.342*	*0.675*	6.643 ***
KZ Index	457	0.537	7.558	*2.326*	*-0.050*	-2.924 **
Market variables						
Return volatility	474	0.133	0.086	*0.171*	*0.121*	-5.673 ***
Stock return	474	-0.006	0.598	*-0.317*	*0.096*	6.780 ***
Trading characteristics						
Net purchase 6m	474	0.004	0.128	*0.029*	*-0.004*	-2.451 **
Net purchase 6–12m	474	0.006	0.143	*0.028*	*-0.001*	-1.880 *
Net purchase 12–24m	474	-0.001	0.069	*-0.001*	*-0.001*	0.015
No. of trades 0–6m	474	5.105	6.454	*5.556*	*4.958*	-0.869
No. of trades 6–12m	474	4.080	6.218	*2.256*	*4.678*	3.7048 ***
No. of trades 12–24m	474	8.574	10.837	*4.265*	*9.986*	5.0841 ***
Active insiders 0–6m	474	0.316	0.283	*0.513*	*0.251*	-9.4643 ***
Active insiders 6–12m	474	0.236	0.259	*0.176*	*0.256*	2.9057 **
Active insiders 12–24m	474	0.414	0.325	*0.321*	*0.445*	3.6336 ***

This table reports the descriptive statistics of the independent variables used in the study. The statistics are provided for the whole sample and insolvent and solvent control firms separately. The mean difference t-test compares the mean values of the variables between insolvent and control firms under the null hypothesis that the mean values of the variables across the two sub-samples are equal. ***, **, * indicate that t-test is significant at 1%, 5%, and 10% respectively. The definitions of variables are provided in Table 2.

Table 4

Logit models: insider trading and the likelihood of insolvency

	(1)	(2)	(3)	(4)
Board size	-0.218**	-0.210**	-0.185*	-0.284**
	[0.094]	[0.096]	[0.099]	[0.113]
Board independence	-1.763*	-1.721*	-1.343	-1.278
	[0.970]	[0.987]	[1.021]	[1.138]
Board ownership	-0.140	-0.217	-0.057	-0.190
	[0.867]	[0.897]	[0.882]	[0.957]
Institutional portfolio	1.612***	1.729***	1.758***	1.764***
	[0.427]	[0.435]	[0.452]	[0.488]
Size	-0.147	-0.136	-0.140	-0.105
	[0.128]	[0.131]	[0.137]	[0.150]
Leverage	3.168***	3.032***	2.859***	2.819***
	[0.745]	[0.755]	[0.776]	[0.852]
Dividend	-0.641*	-0.584*	-0.477	-0.414
	[0.333]	[0.338]	[0.363]	[0.389]
Return volatility	6.055***	6.148***	6.533***	7.453***
	[1.814]	[1.846]	[2.011]	[2.129]
Stock return	-1.562***	-1.555***	-1.691***	-1.843***
	[0.274]	[0.277]	[0.305]	[0.342]
Net purchase 0–6m		**9.179***		
		[4.710]		
Net purchase 6–12m		**0.496**		
		[5.758]		
Net purchase 12–24m		**-1.779**		
		[1.878]		
No. of trades 0–6m			**0.092*****	
			[0.027]	
No. of trades 6–12m			**-0.066****	
			[0.033]	
No. of trades 12–24m			**-0.112*****	
			[0.027]	
Active insiders 0–6m				**3.604*****
				[0.623]
Active insiders 6–12m				**-1.201***
				[0.657]
Active insiders 12–24m				**-2.600*****
				[0.565]
Constant	14.676	2.372	1.718	1.567
	[31.126]	[2.166]	[2.253]	[2.445]
N	474	474	474	473
Log-likelihood value	-178.039	-175.059	-161.465	-141.473
Pseudo R^2	0.328	0.339	0.390	0.465

This table presents the results of the logistic regressions between the dichotomous insolvency variable and the insider trading variables. Other accounting, marketing and corporate governance variables are also included as control variables. All models include time and industry dummies. The definitions of variables are provided in Table 2. ***, **, * indicate that the estimated coefficient is significant at the 1%, 5%, and 10% levels respectively. Standard errors are reported in bracket

Table 5

Logit models: insider trading and the likelihood of insolvency

	(1)	(2)	(3)
Board size	-0.346***	-0.338***	-0.366***
	[0.076]	[0.078]	[0.087]
Board independence	-1.413*	-0.948	-0.796
	[0.849]	[0.878]	[0.993]
Institutional portfolio	1.250***	1.244***	1.411***
	[0.381]	[0.396]	[0.434]
KZ Index	0.181***	0.158**	0.102
	[0.064]	[0.066]	[0.066]
Net purchase 0–6m	**10.298****		
	[4.311]		
Net purchase 6–12m	**-0.760**		
	[5.098]		
Net purchase 12–24m	**-0.883**		
	[1.659]		
No. of trades 0–6m		**0.115*****	
		[0.027]	
No. of trades 6–12m		**-0.084*****	
		[0.032]	
No. of trades 12–24m		**-0.124*****	
		[0.027]	
Active insiders 0–6m			**4.075*****
			[0.579]
Active insiders 6–12m			**-1.510*****
			[0.563]
Active insiders 12–24m			**-2.411*****
			[0.519]
Constant	2.285**	1.769*	1.422
	[0.952]	[1.006]	[1.138]
N	457	457	457
Log-likelihood value	-207.609	-188.316	-166.899
Pseudo R^2	0.188	0.263	0.347

This table presents the results of the logistic regressions between the dichotomous insolvency variable and the insider trading variables. Accounting and market variables used in Table 4 are replaced with the KZ-Index in all estimations. Corporate governance variables are also included as control variables. All models include time and industry dummies. The definitions of variables are provided in Table 2. ***, **, * indicate that the estimated coefficient is significant at the 1%, 5%, and 10% levels respectively. Standard errors are reported in brackets.

Table 6

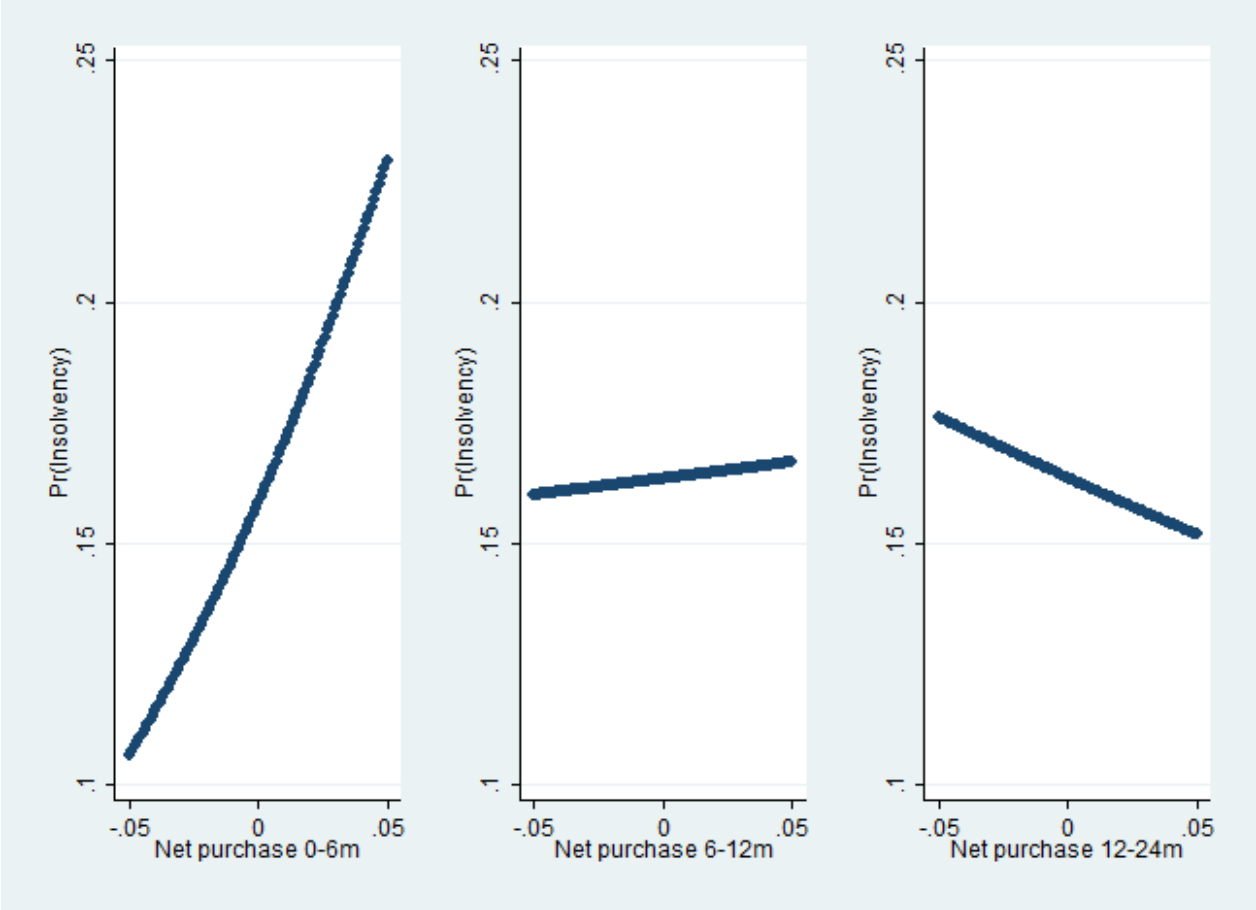
Robustness table

	(1)		(2)		(3)
Size of purchases 0–6m	22.574***	**No. of purchases 0–6m**	0.105***	**Active executives 0–6m**	1.501***
	[7.274]		[0.029]		[0.414]
Size of purchases 6–12m	-5.903**	**No. of purchases 6–12m**	-0.082**	**Active executives 6–12m**	-0.369
	[2.388]		[0.038]		[0.331]
Size of purchases 12–24m	-8.666**	**No. of purchases 12–24m**	-0.109***	**Active executives 12–24m**	-0.948***
	[4.143]		[0.030]		[0.343]
Size of sales 0–6m	-0.165	**No. of sales 0–6m**	0.001	**Active non-executives 0–6m**	1.323***
	[1.887]		[0.092]		[0.335]
Size of sales 6–12m	-2.513	**No. of sales 6–12m**	-0.033	**Active non-executives 6–12m**	-0.333
	[3.627]		[0.092]		[0.356]
Size of sales 12–24m	-1.125	**No. of sales 12–24m**	-0.121**	**Active non-executives 12–24m**	-1.536***
	[2.393]		[0.060]		[0.353]
Constant	2.204		1.779		1.148
	[2.218]		[2.261]		[2.461]
N	474		474		474
Log-likelihood value	-168.743		-160.74		-142.93
Pseudo R^2	0.363		0.3932		0.4604

This table presents the results of the logistic regressions between the dichotomous insolvency variable and the insider trading variables by incorporating purchase and sale transactions separately in Models1 and 2, and the trades carried out by executives and non-executive directors in Model 3. For brevity, we do not report accounting, marketing and corporate governance variables that are included in the models as control variables. The findings regarding the control variables are in line with the previous findings. All models include also time and industry dummies. The definitions of variables are provided in Table 2. ***, **, * indicate that the estimated coefficient is significant at the 1%, 5%, and 10% levels respectively. Standard errors are reported in brackets.

Figure 1

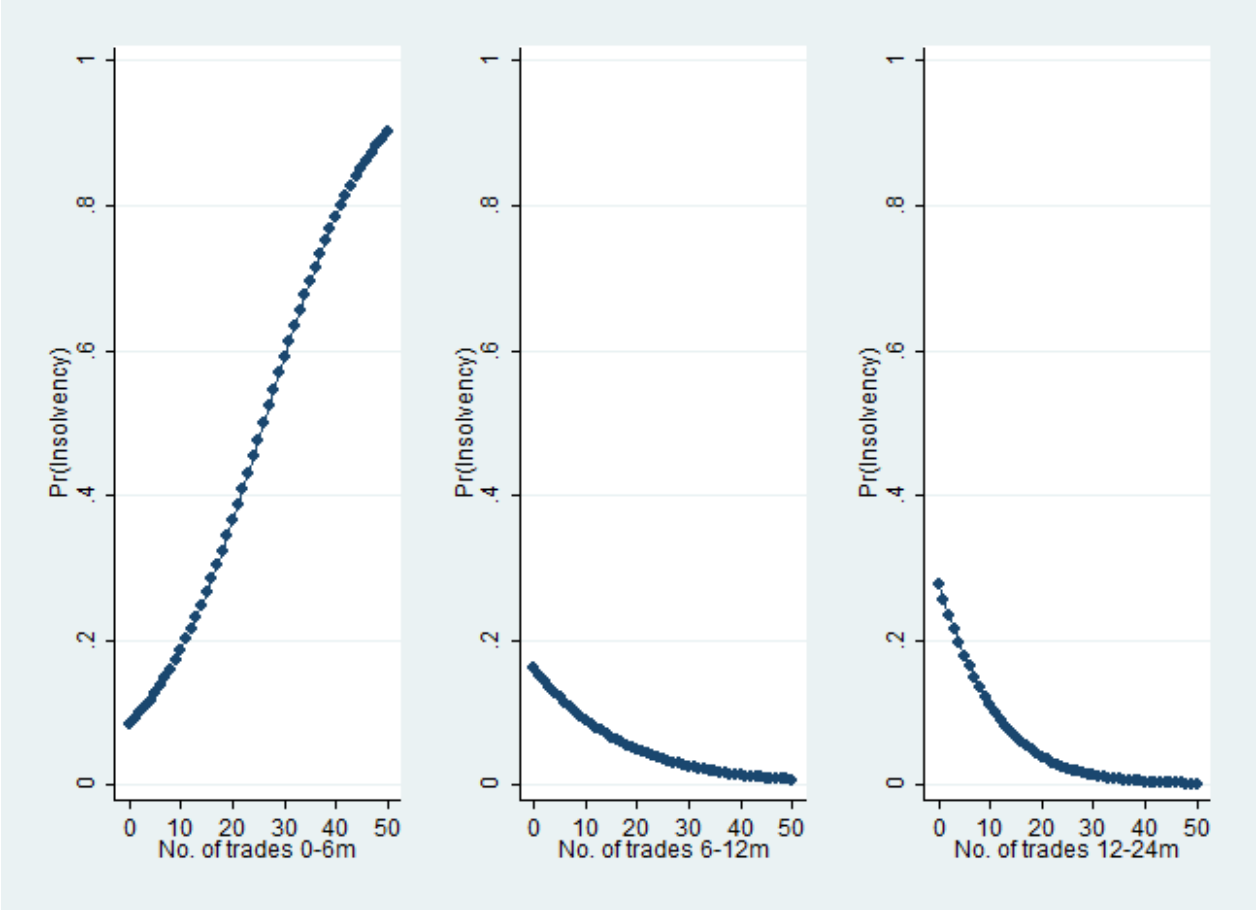
The relationship between probability of insolvency and net purchase



These figures plot the probabilities of insolvency for values of net purchase across three windows, i.e. 0–6 months, 6–12 months, and 12–24 months, using the logit model estimated as Model 2 in Table 4. All remaining independent variables are evaluated at the sample mean. The definitions of all variables are provided in Table 2.

Figure 2

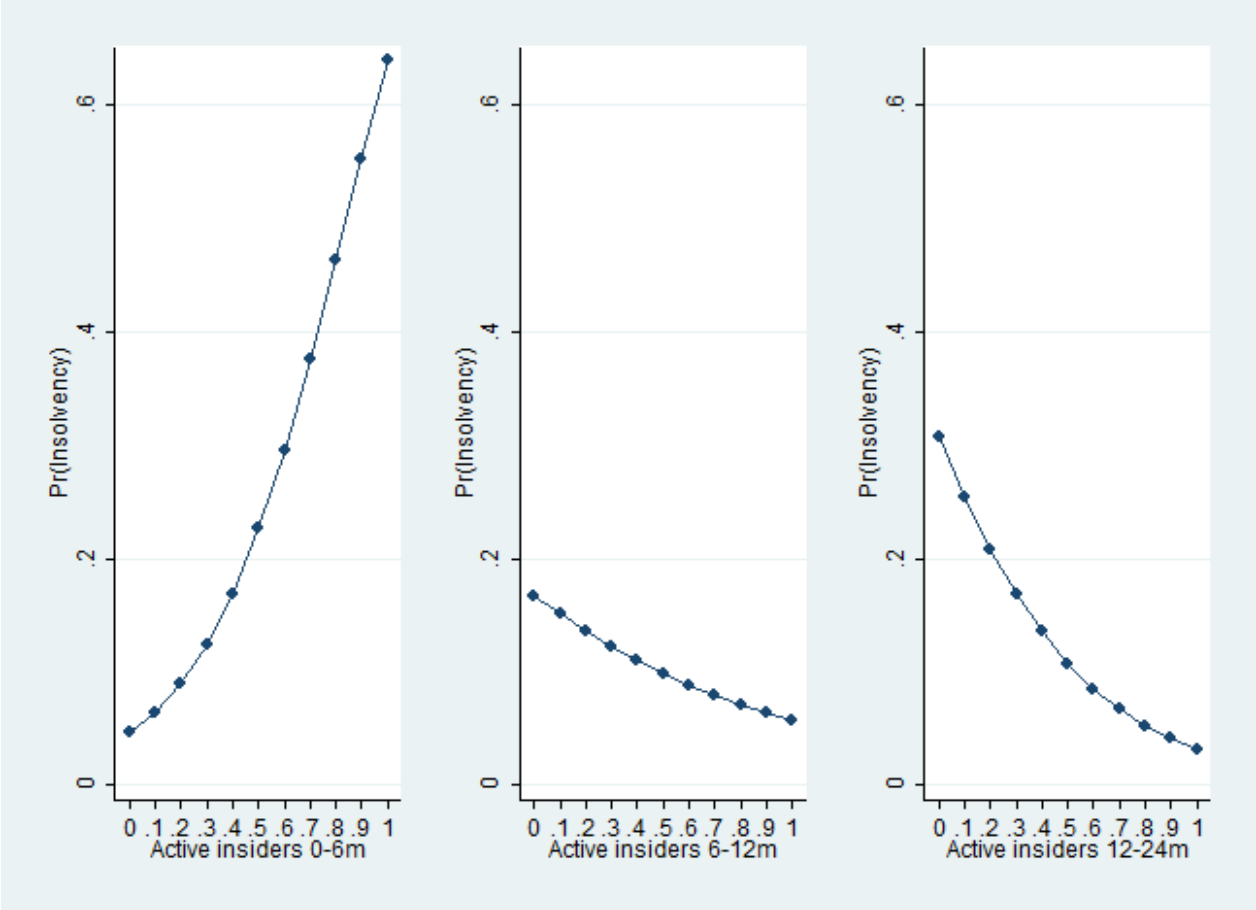
The relationship between probability of insolvency and number of trades



These figures plot the probabilities of insolvency for number of trades across three windows, i.e. 0–6 months, 6–12 months, and 12–24 months, using the logit model estimated as Model 3 in Table 4. All remaining independent variables are evaluated at the sample mean. The definitions of all variables are provided in Table 2.

Figure 3

The relationship between probability of insolvency and ratio of active insiders



These figures plot the probabilities of insolvency for ratios of activity of members of boards across three windows, i.e. 0–6 months, 6–12 months, and 12–24 months, using the logit model estimated as Model 4 in Table 4. All remaining independent variables are evaluated at the sample mean. The definitions of all variables are provided in Table 2.