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# Mobile Financial Information Services: Capabilities of Suitable Push Services

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## Abstract

*According to the theory of efficient markets, prices of individual securities reflect all information available to the capital market. Therefore, new information such as ad hoc disclosures should be priced into stock quotations very quickly. If such significant price effects and enough effect delays can be observed, investors should be informed about relevant market events very quickly. Therefore, this paper analyzes prompt short-run stock market reactions caused by company announcements. Our study shows that the observed intraday price effects and effect delays ask for appropriate mobile notification services. After identifying relevant characteristics of suitable notification services we evaluate different mobile push service technologies. We can show how private investors can be informed about critical market events in time, using most adequate mobile push services.*

**Keywords:** E-Finance, Mobile Financial Information Systems

## 1. Introduction and Motivation

This study examines the potential of personalized financial information push services to face security market effects caused by ad hoc disclosures published by publicly listed German companies. Assuming an efficient capital market, new information should be priced in stock market rates very quickly. In contrast to most existing studies (Röder 1999; Nowak 2001) of the German capital market, we focus on short-run price effects. Whereas our study bases on extensive intraday stock prices taken from Frankfurt Stock Exchange (floor and the electronic trading platform XETRA), these existing studies work with manageable interday closing prices and examine long-term effects.

After analyzing the stock market reactions (measured by price reactions) we examine the intraday speed of stock price adjustments and define suitable information technology characteristics to derive appropriate push service infrastructures. Using these characteristics we compare potential mobile push service technologies and propose suitable mobile push services for implementing an appropriate notification service. We can show that WAP Push Message provides the most of the demanded service requirements and consequently is the most suited one for implementing an adequate mobile financial information service.

There are many studies analyzing market reactions caused by new information available to the capital market. Most of these studies focus on the Anglo-American market and examine interday-behavior. However, Patell and Wolfson (1984) examine the intraday speed of stock

price reactions to earnings and dividend announcements. They show that most of the price reactions occur in the first five to fifteen minutes after the announcement. Woodruff and Senchak (1988) observe intraday price reactions to unexpected earnings. They find direct market reactions and delays up to one hour. Barclay and Litzenberger (1988) analyze market reactions on announcements of new equity issues also on intraday basis. For fifteen minutes following the publication, an abnormal high trading volume and a negative average return can be observed.

The availability of powerful financial information systems has improved the information supply during the recent years. Besides professional terminal systems, web-based market information systems support private investors making their investment decisions. The emergence of powerful mobile devices might forward this trend. All these new information systems lead to contemporary information supply which might increase market efficiency. Furthermore personalized mobile information systems might support private investors observing market developments. These services could equate the information supply of private investors with the supply of institutional investors.

Today, there is no work which examines intraday price effects covering the influence of the new financial information system of the recent years. If significant price effects and effect delays following the ad hoc disclosures could be detected, the existence of personalized mobile push services could improve the reaction time of investors. It is of utmost importance that there is enough effect delay, otherwise non-institutional investors will not be able to react in time. Consequently an up-to-date price effects analysis which covers the development of market information and transaction services of recent years is required.

As accordant price effects reveal the potential of mobile information services, an analysis of information service requirements and existing mobile push service technologies provides evidence for implementing such services.

## **2. Event Study Approach**

### ***2.1 Dataset***

This study focuses on ad hoc disclosures published by the Deutsche Gesellschaft für Ad-hoc-Publizität (DGAP) pursuant to Section 15 of the German Securities Trading Law (WpHG). This paragraph regulates under which circumstances companies have to publish ad hoc disclosures in Germany. The publication itself is done (85% in 2003) by DGAP on behalf of the companies in most cases. At first, DGAP sends these company announcements to the stock exchanges and the regulatory authorities to fulfill legal requirements (Deutsche Gesellschaft für Ad-hoc-Publizität 2002). After this, the disclosure is published via several news services. For this analysis we use the DPA-AFX news feed, which contains among other news all ad hoc disclosures published by the DGAP. For each disclosure exists the exact wording and the exact timestamp to the second. Consequently it is possible to automate the storage and following further processing because each announcement can be identified by this unique timestamp.

The empirical analysis enfolds the time frame between 2003-08-01 and 2004-02-29. Our announcement dataset consists of 1398 ad hoc disclosures. The temporal distribution of this sample is shown in figure 1.

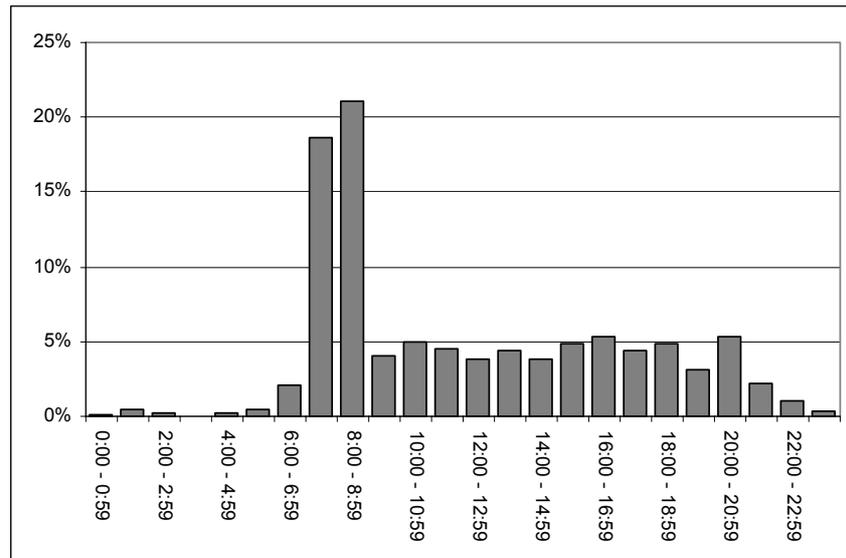


Figure 1. Temporal distribution of the ad hoc disclosure sample.

It is noticeable that most ad hoc disclosures are published during the two hours before trading begins. This behavior can be explained as prevention of suspended trading.

Because we concentrate on the German capital market, we discard ad hoc disclosures published by companies which issued non-domestic shares only. Confounding events have significant impact on results of empirical tests, so we eliminate these by identifying companies which publish more than one disclosure per day. The disclosures of that day and the respective company are not taken for the sample. Because we want to observe intraday short-run behavior we focus on ad hoc disclosures published during trading hours. As we want to measure the price reaction following ad hoc disclosures we decided that there must be at least twenty price fixings (ticks) after the disclosure, otherwise it is not part of the dataset. This is done for two reasons. First, an intraday price analysis of illiquid assets is not practical because there must be enough price information available to perform a sound analysis of the price reaction. Secondly, these discarded stocks are very illiquid assets and so neglected by the investors.

Table 1 shows the number of ad hoc disclosures published between 2003-08-01 and 2004-02-29 by DGAP and how our dataset filters reduce the size of the dataset. Identical announcements published in different languages have been treated as one disclosure.

Reason of revision	Number of Disclosures
Master data	1399
Elimination of non-domestic stocks	95
Elimination of confounding events	60
Elimination of disclosures not published during trading hours	688
Elimination because of insufficient price ticks after the announcement	408
Remaining dataset size	148

Table 1. Master data filtering and dataset size.

Given the ad hoc disclosures published during the observation period, we were able to extract the stock exchange symbol of the publishing company for each disclosure automatically. Using this symbol, we request the intraday price series of that stock beginning ten days before and until the disclosure date. The nine days before the observed event are defined as

comparison period whereas the publication date is defined as day of the observed event. Given these price fixings for ten days, we aggregated all price information observed during a time frame of one minute to one price information using the last price fixing (close) of this period.

We made this aggregation for two reasons. First we had to reduce the data to be processed to a manageable complexity. Secondly, we want to correct the price information by adjusting general market effects with a common market index. As the price information of indices are not calculated every second it was necessary to have consistent timestamps. So we decided to work with price information exact to the minute as it is a compromise between manageability and accuracy.

All stock prices were taken from the fully electronic trading system XETRA trading platform operated by Deutsche Börse Group, which is an electronic trading system aggregating buy and sell orders of licensed traders and from the Frankfurt Stock Exchange (floor trading). XETRA covers more than ninety percent of the entire share trading in Germany (Deutsche Börse Group 2003). Nearly twenty percent of these orders are placed by private investors which shows that this customer segment also uses the new electronic information and transaction systems.

We use intraday price series from 2003-07-22 (first analyzed ad hoc disclosure date minus nine prior days) to 2004-02-29 in the time frame from 9am to 8pm and 9am to 5:30pm (XETRA operating hours changed during our analysis). To isolate price effects caused by the ad hoc disclosure, we apply a single-index model by using intraday price series (exact to the minute) of the CDAX Performance Index (ISIN: DE0008469602) from XETRA for the same period. The CDAX index contains all domestic companies from the market (segments Prime and General Standard), so it represents the entire range of the German equity market.

## 2.2 Event Study Design

We are starting with the calculation of discrete returns for company  $i$  at time  $t$  using intraday prices  $P$ .

$$R_{i,t} = \frac{P_{i,t+1} - P_{i,t}}{P_{i,t}} \quad (1)$$

These returns are calculated for all existing prices (and companies) starting ten days before the day of the ad hoc disclosure. These calculated returns represent the intraday stock price developments of company  $i$  over a 10 day period. The CDAX returns are calculated accordingly.

To isolate the price effect caused by the ad hoc disclosure, these returns have to be adjusted by general market developments. Doing so, the corrected return series should reflect the price effects caused by the ad hoc disclosure only. In our work we are calculating net-of-market-returns to isolate the disclosure effect. These abnormal returns ( $AR_{i,t}$ ) are calculated by subtracting the index (CDAX) returns from the stock returns  $R_{i,t}$ .

$$AR_{i,t} = R_{i,t} - R_{CDAX,t} \quad (2)$$

Klein and Rosenfeld (1987) examine the quality of different return-generating models for calculating abnormal returns. They show that the single index model (calculating market-adjusted returns) we use leads to analogous results compared to the OLS market model. Brown and Warner (1985) analyze the quality of different methodologies for calculating

abnormal returns. They find that the single index model and the OLS market model outperform the simpler mean adjusted returns procedure.

Because we do not make any ex ante classification, positive and negative disclosures might neutralize. Therefore, the absolute values of  $AR_{i,t}$  are used in the following. These absolute abnormal returns ( $AAR_{i,t} = |AR_{i,t}|$ ) cannot be used for any statistical test, because rejecting the null hypothesis that ‘a sum of absolute values is zero’ would be possible with the utmost probability. For that reason an adjustment according to Carter and Soo (1998) has to be done. We are therefore calculating the average absolute abnormal returns ( $AAAR_i$ ) for the comparison period for nine days starting ten days before the disclosure timestamp (for time intervals to the minute, which means up to 11 hours \* 60 min \* 9 days = 5940 prices per company depending on the price ticks received from the stock exchanges). We exclude the day prior to the event day, because these prices might be affected by insider dealing or anticipation effects.

$$AAAR_i = \frac{\sum_{t=1}^T |AR_{i,t}|}{T} \quad (3)$$

The absolute abnormal returns  $|AR_{i,t}|$  of the event day are corrected by these averages. The result is called corrected absolute abnormal return ( $CAAR$ ).

$$CAAR_{i,t} = |AR_{i,t}| - AAAR_i \quad (4)$$

In comparison to Carter and Soo (1998) our  $CAAR$  can be interpreted easily because we do not standardize (4). The  $CAAR$  is the part of the absolute abnormal returns, lying above the level which can be observed on an average when no ad hoc disclosure is published. Rohrback and Chandra (1989) have shown that tests using absolute prediction errors are more powerful than using squared errors.

For our statistical tests we calculate cumulated corrected absolute abnormal returns  $CCAAR_{t1,t2}$  for a time frame starting with the first price information available after the disclosure timestamp. The time frame between  $t1$  and  $t2$  is dynamic, because we calculate  $CCAAR_{t1,t2}$  for a given number ( $t2-t1$ ) of price fixings.

$$CCAAR_{t1,t2} = \sum_{t=t1}^{t2} CAAR_{i,t} \quad (5)$$

To estimate the price reaction we calculate  $CCAAR_{t1,t2}$  for  $(t1,t2) = (1,2), (1,5), (1,10), (1,20)$  whereas  $t1$  is defined as the timestamp of first price fixing available after the ad hoc disclosure and  $t2$  as the timestamp of the last price fixing of the observed time frame. The time frame between  $t1$  and  $t2$  is the elapsed time between the first observed price ( $t1$ ) and the last observed price ( $t2$ ).

We calculate these  $CCAAR_{t1,t2}$  for each time frame and ad hoc disclosure. The  $CCAAR_{t1,t2}$ s of a time frame can be understood as a distribution of  $CCAAR$ s. A distribution example ( $CCAAR_{1,2}$ ) is shown in figure 2.

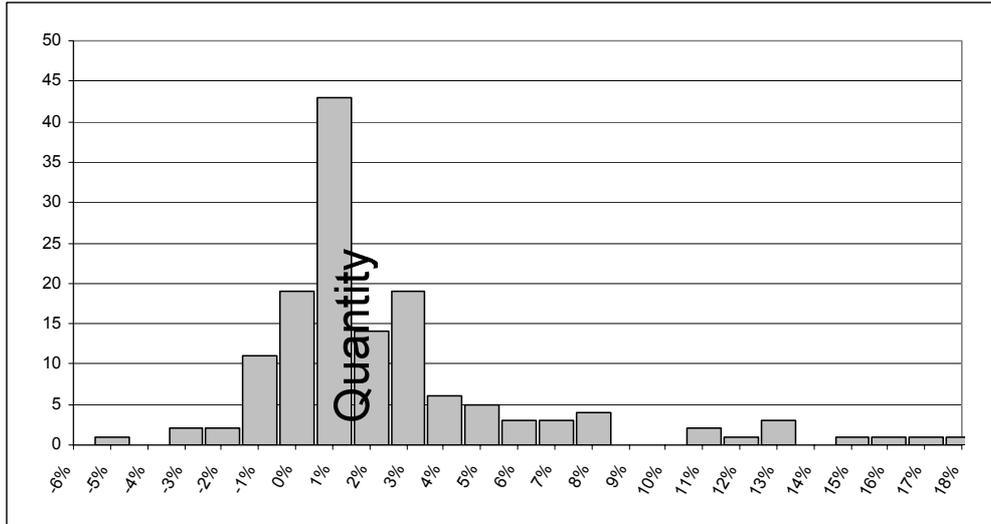


Figure 2. Distribution of CCAAR for the time frame (1,2).

These distributions are taken for testing the existence of significant abnormal returns caused by the published ad hoc disclosure.

### 2.3 Test Statistics under the Null Hypothesis

Given the cumulated corrected absolute abnormal returns  $CCAAR_{t1,t2}$  for each ad hoc disclosure and time frame we evaluate the statistical significance of the event period's abnormal returns. The null hypothesis  $H_0$  to be proven is that the average  $CCAAR_{t1,t2}$  over all disclosures is equal to zero. A significant price effect caused by ad hoc disclosures within the time frame  $t1$  and  $t2$  can be statistically proven if the null hypothesis can be rejected.

$$H_0 : E(CCAAR_{t1,t2}) = 0 \quad \text{vs.} \quad H_1 : E(CCAAR_{t1,t2}) > 0$$

We can not assume that the sample distribution of  $CCAAR_{t1,t2}$  is normal. But having a sample size greater than thirty, the distribution of the sample means is approximately standard normal (Groebner et al. 1999). Therefore, we calculate  $t$ -values for the different time frames.

$$t_{t1,t2} = \frac{\bar{x} - \mu}{\frac{s}{\sqrt{n}}} \quad (6)$$

For each time frame ( $t1,t2$ ) we perform a  $t$ -test to prove if company announcements cause abnormal intraday returns within the defined time frames after the disclosure has been published. If we can reject the hypothesis  $H_0$  for a time frame we can show abnormal returns for that time frame at a certain significance level.

### 2.4 Empirical Results

We suppose that due to the emergence of powerful information systems in recent years, the capital market reacts very quickly to new information. At first, we perform five tests regarding the significance of the abnormal returns (\*\* indicates significance on the 1% level; \* on the 5% level; \* on the 10% level).

	$CCAAR_{1,2}$	$CCAAR_{1,5}$	$CCAAR_{1,10}$	$CCAAR_{1,15}$	$CCAAR_{1,20}$
Mean	0.0361	0.0447	0.0531	0.0538	0.0495
T-Value	4.71***	4.33***	2.98***	2.07**	1.47*

Table 2. Intraday price changes after ad hoc disclosures.

As shown in table 2 we detect significant abnormal returns for all time frames starting with the first price fixing after the ad hoc disclosure is published. This finding corroborates our hypothesis that the market will react very quickly to new information. Because we want to prove the potential of personalized mobile information services we have to determine a maximum reaction time in which abnormal returns can be observed. Thus we conduct *t*-tests for the observed time frames sequentially.

	$CCKAAR_{1,2}$	$CCKAAR_{2,5}$	$CCKAAR_{5,10}$	$CCKAAR_{10,15}$	$CCKAAR_{15,20}$
Mean	0.0361	0.0086	0.0085	0.0007	-0.0043
T-Value	4.71***	1.40*	0.88	0.07	-0.49

Table 3. Intraday price changes after ad hoc disclosures for different time slots.

The separated tests of the observed time frames show, that we can not detect significant abnormal returns for all periods. We can observe abnormal returns for the first two sequential time frames (1,2) and (2,5) at the significance level of 1% and 10%. This confirms a very quick market reaction because the price adjustments are completed within the first five price fixings. A capable mobile information system would have to inform about the new information within this time frame.

Because these time frames are based on price fixings (exact to the minute), we convert these to corresponding time data. Therefore, we determine the consumed time at which 2, 5, 10, 15 and 20 stock prices are fixed after the announcement. Doing this for all ad hoc disclosures, we are able to calculate means for the analyzed time frames.

Time Frame	(1,2)	(1,5)	(1,10)	(1,15)	(1,20)
Mean in Minutes	12.8	25.7	53.1	84.2	127.0
Time Frame	(1,2)	(2,5)	(5,10)	(10,15)	(1,20)
Mean in Minutes	12.8	12.9	27.4	31.1	42.8

Table 4. Conversion of ticks to minutes.

Taking the figures of table 4 we can show that there are significant abnormal returns approximately within 25,7 minutes after the ad hoc announcement has been published (we observed significant abnormal returns for the first two sequential time frames (1,2) and (2,5)). It is remarkable that within the elapsed time the significance of the observed abnormal returns decreases. A differentiation between blue chips and small caps would be advisable and is intended but not possible with our current sample size.

The observed delays in price reactions open a window of opportunity for investors. If these investors are not informed promptly they cannot react immediately to new market information. Because non-institutional investors are usually not able to analyze all portfolio relevant market information continuously, highly personalized mobile push services might bridge this gap. These services could move private investors on a level playing field with their institutional counterparts. Therefore, the monitoring of investors' portfolio status and new market events have to be done server-side by online brokers. In case of a relevant market

event (i.e. a company whose stocks are held by the investor publishes an ad hoc disclosure) the investor can receive notification via a mobile push service.

### **3. Event Notification and Push Service Infrastructures**

There are several mobile push service technologies available, having different assets and drawbacks. Therefore, the following chapter gives an overview regarding different mobile push services coming into consideration and their properties being relevant for a suitable notification service. Furthermore, an evaluation of these properties is done in order to compare them with the requirements of the proposed event-triggered mobile notification services.

#### ***3.1 Notification Service Requirements***

An appropriate notification service would have to combine several features. Notification characteristics relevant for this evaluation have to be identified and compared with the characteristics of the considered mobile push services. The feature required most fundamentally is the ability to send textual information. A suitable event notification would contain information regarding the event which triggered the notification and which portfolio position is expected to be affected. Depending on the maximum message length the notification might contain the original announcement text published by the company. Furthermore, the attachment of multimedia content can be sensible (e.g. an intraday chart of the affected stock) but is not mandatory, because of the limited available reaction time. If a notification requires quick portfolio transactions, the notification message should link to a transaction service enabling the investor to buy or sell affected portfolio positions. For the same reason, the push service should provide real time push capabilities and should not depend on spare capacity of the underlying network.

A big problem with message services is the level of user-intrusiveness caused by unwanted or outdated messages. This problem is even more relevant when using mobile devices, because of limited device capabilities and lower connection speed. Consequently the usage of message meta-information would help to define priority levels and add expiration control. When using priority levels, the investor is able to reduce the amount of messages or can react to very relevant announcements only. Furthermore, an expiration control might also decrease the level of user-intrusiveness because outdated messages can be deleted automatically. Consequently, we define the following push message characteristics to be relevant for the proposed financial notification service:

- Text content including maximum message length
- Multimedia content attachments
- Link to web/wap transaction services
- Notification lifetime control (expiration date)
- Priority levels of notifications
- Real-time push

### 3.2 *An Evaluation of Appropriate Mobile Push Services*

The analyzed mobile push message services show significant differences regarding technical specification. The following evaluation abstracts from technical details and concentrates on specialties being relevant on the application level of mobile financial notification services. Therefore, the evaluation of message services to be considered is done using the message characteristics defined in chapter 3.1. Finding an appropriate mobile push service can so be achieved in a systematic way. We concentrate on four mobile push services, namely Short Message Service (SMS), Multimedia Message (MMS), WAP Push Message and WAP Multimedia Push. The first prominent mobile push service is part of the GSM Phase 1 standard since 1992 (ETSI 1992). SMS is supported by nearly all mobile GSM devices and networks today. Consequently this service has access to a large installed basis. Multimedia Messages have been introduced in 2001 (WAP Forum 2001a). The major difference between SMS and MMS is the rich set of multimedia content types supported by MMS, which is not a deciding functionality for our notification service. More relevant is that no maximum size for MMS messages has been specified compared with the SMS size limitation of 160 characters. Both services follow a store-and-forward paradigm and do consequently not feature real-time messaging (ETSI 1992; WAP Forum 2001a). They do not support any message meta-information to define a priority level and an expiration date. Consequently they have no functionality which can be used to reduce the level of user-intrusiveness. They can also not link to any external services, so direct linking to transaction services is not possible.

The WAP push services were introduced in the WAP 1.2 specification in 1999 (WAP Forum 1999) and have been enhanced in the WAP 2.x specification in 2001 (WAP Forum 2001b). These specifications were published by the WAP Forum which joined the Open Mobile Alliance (OMA) in 2002. WAP Push Messages and WAP Multimedia Messages both support textual content but only WAP Multimedia Messages support Multimedia content. A notification is sent by a push initiator (e.g. a server which observes a news feed and the current portfolio status) to the Push Proxy Gateway (PPG) which sends a Session Initiation Requests (SIR) via Short Message Service to the mobile device. The mobile device contacts the PPG, which sends the push message to the mobile device (WAP Forum 2001b). Consequently WAP Push Services are subject to the restrictions of SMS and do not support real-time push functionality. If the Push Proxy Gateway is not able to contact the mobile device within a defined time frame, a timeout will be triggered. Whereas WAP Push Messages support linking to external services (service indication or service loading) and message meta-information (message expiration date and priority), WAP Multimedia Messages do not support these features. The following table summarizes the functionality provided by the considered mobile push services according to the required characteristics defined in 3.1.

	SMS	MMS	WAP Push Message	WAP Multimedia Push
Textual Content	Yes <sup>1</sup>	Yes	Yes	Yes
Multimedia Content	No	Yes	No	Yes
Link to external Services	No	No	Yes	No
Message Expiration Date	No	No	Yes	No
Message Priority	No	No	Yes	No
Real-time Push	No	No	No	No

<sup>1</sup> maximum length of 160 characters

*Table 5. Push service functionality overview.*

SMS and MMS are both extensively inappropriate, because both message services provide basic functionality only. WAP Multimedia Push is able to process multimedia content, but can not link to external services and does not support message meta-information. It is remarkable that WAP Push Message provides most of the required features for designing a suitable mobile notification service. Compared with WAP Multimedia Push it does not provide multimedia content support but provides all other required functionality except for real-time push. Consequently, we propose usage of WAP Push Messages for designing a suitable mobile financial notification service. An appropriate notification would contain the notification text and a link to an external trading system. To decrease the level of user-intrusiveness it contains an expiration date (e.g. 30 minutes after the announcement has been published according to the results of section 2.4) and a priority level. This level could be set depending on the asset value affected by the announcement. The following figure illustrates how a typical WAP Push Message (Service Indication) would look like.

```

WAP Push Message (Service Indication)
<?xml version="1.0"?>
<!DOCTYPE si PUBLIC "-//WAPFORUM//DTD SI 1.0//EN"
"http://www.wapforum.org/DTD/si.dtd">
<si>
<indication href="http://www.example.org/trade.wml?id=007007"
created="2004-06-20T10:23:15Z"
si-expires="2004-06-20T10:53:15Z"
action= "signal-high">
  You have 1 new notification
  User-intrusiveness level: high
  Expiration Date: 2004-06-20 10:38:45
  Company XY has published a portfolio relevant announcement
</indication>
</si>

```

*Figure 3. WAP Push Service Indication (SI) example*

In the example push message described in figure 3 the investor gets informed about a relevant company announcement. The announcement expires after thirty minutes and has a high priority level (e.g. because the investors hold many stocks of the company).

#### 4. Summary and outlook

Our event study confirms the existence of abnormal returns caused by ad hoc disclosures on the German capital market. In comparison to former research, we use extensive intraday price series in contrast to daily close prices and observe that new information is priced into stock quotes quickly. We detect significant abnormal returns within less than thirty minutes after the announcement has been published which opens a window of opportunity.

Because private investors will not be able to react within this range without appropriate technical support, we suggest personalized mobile push services which inform about relevant company announcements immediately. An appropriate notification service has to feature several characteristics in order to notify investors in time and keep the user-intrusiveness at a passable level. Therefore we propose the WAP Push Messages service because it combines the most relevant characteristics for designing an appropriate mobile notification service.

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