The effect of Economic Data Releases on Foreign Exchange Markets based on high frequency data

Andrés A. Bagnasco,* Nicolás Sánchez y Juan C. Sapriza*****

Abstract. *Using six years of high-frequency (tick) foreign exchange spot quotes between January 2003 and June 2008, as well as economic announcement schedules from G7-countries, we study the effect of the most relevant macroeconomic data releases on EURUSD, GBPUSD, USD/JPY, USDCHF, AUDUSD, USDCAD, EURGBP and EURJPY. Tick frequency, volatility indicators and average market-maker spreads were considered. The hypothesis about the important impacts of economic announcements over exchange rates, as well as the lack of a reliable and quantitatively-based extensive classification of these announcements were the main drivers of our research. We confirm the importance of some of the most influential announcements for each of the G-7 countries. We also validate the practice of certain hedge fund managers of staying position-neutral during certain major data releases in order to avoid exposure to excessive volatility, as well as supplying hedge funds/risk managers, traders and market practitioners with a detailed «data release catalogue» for supporting their risk management decisions. Finally, clean and reliable datasets become now available for future research, removing the entry barriers researchers' usually face in this area.*

Keywords: *ECONOMIC ANNOUNCEMENTS / TICK DATA / FOREIGN EXCHANGE MARKET (FOREX) / NEWS / TRADING / DATA RELEASES.*

Resumen. *Empleando datos de tipo de cambio* spot *de alta frecuencia (*tick*) entre enero de 2003 y junio de 2008, así como calendarios de difusión de información económica de países del G-7, se estudia el efecto de estos anuncios sobre las cotizaciones de seis pares de monedas empleando variables como la frecuencia de ticks, indicadores de volatilidad y spreads. Las principales motivaciones para este estudio son la importancia del impacto de los anuncios de información económica sobre las cotizaciones y la falta de clasificaciones extensivas de indicadores de anuncios económicos basados en datos cuantitativos, provenientes de fuentes confiables. El estudio confirma la existencia de impacto de los principales indicadores sobre los tipos de cambio del G-7. Asimismo, se valida la práctica de gestión de riesgos aplicada por algunos* Hedge Funds, *bajo la cual neutralizan sus posiciones de mercado durante la emisión de importantes anuncios, a fin de evitar su exposición a volatilidades*

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excesivas. Se presenta una herramienta o «catálogo de anuncios» de suma utilidad para gerentes de riesgo, especuladores y gerentes de fondos, con el fin de asistirlos en la toma de decisiones/gestión de riesgos. Finalmente, se ponen a disposición de la comunidad académica fuentes de datos de alta calidad para futuras investigaciones.

Palabras clave: *ECONOMIC ANNOUNCEMENTS / TICK DATA / FOREIGN EXCHANGE MARKET (FOREX) / NEWS / TRADING / DATA RELEASES.*

Objectives

The objective of this paper is to analyze the impact of data releases over G-7 currency spot foreign exchange rates, based on high-frequency quotes (tick) data. The results could validate the risk management practice carried out by some hedge fund managers (e.g. Capricorn FX) which consists in being market-neutral or off-the-market during the release of certain important data/news in order to avoid being exposed to unnecessary volatility.

In order to reach this objective, this work demands, and faces the challenge of creating an empirical knowledge base or "catalog" of economic indicators in order to aid hedge fund managers, risk managers and market practitioners in the decision-making process of whether to be or not in the market during such events. This roadmap is valuable as closing positions before every data release naturally implies trading costs (liquidity/spreads, commissions, opportunity costs, etc.).

Additionally, as consequence of the meticulous sorting of economic announcements, the academic/research community now has the possibility to access to a clean and reliable source of information for future research efforts.

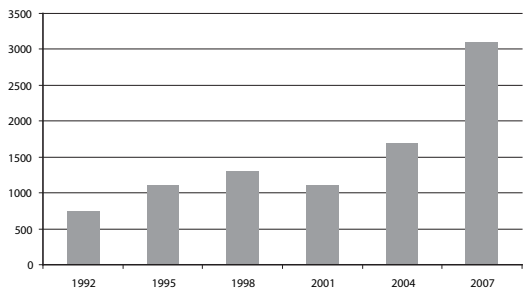
1. Introduction

The Foreign Exchange market is the biggest market in the world, according to the latest Triennial Foreign Exchange Survey (BIS, 2007), over 3.2 billion dollars are traded on average every day. High-frequency traders and hedge funds represent an increasing portion of it. It is a distributed Over The Counter (OTC) global market; spot transactions account for approximately 31% of the overall 2007 turnover.

According to the latest BIS survey (BIS, 2007), a few currencies (US Dollar [USD], Japanese Yen [JPY], Euro [EUR], Great Britain Pound [GBP], Swiss Franc [CHF], Canadian Dollar [CAD] & Australian Dollar [AUD]) known as G-7 account for

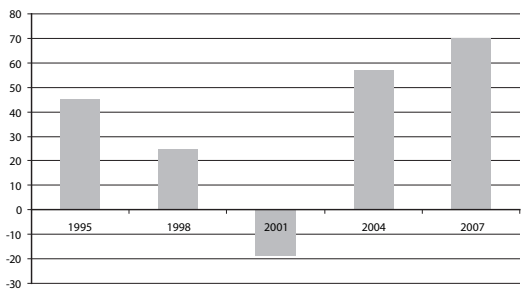
Charts 1 & 2

Daily Volume (USD Billions)



Source: BIS (2007).

Volume Variation (%)*



* Variation vs. previous triennial survey.

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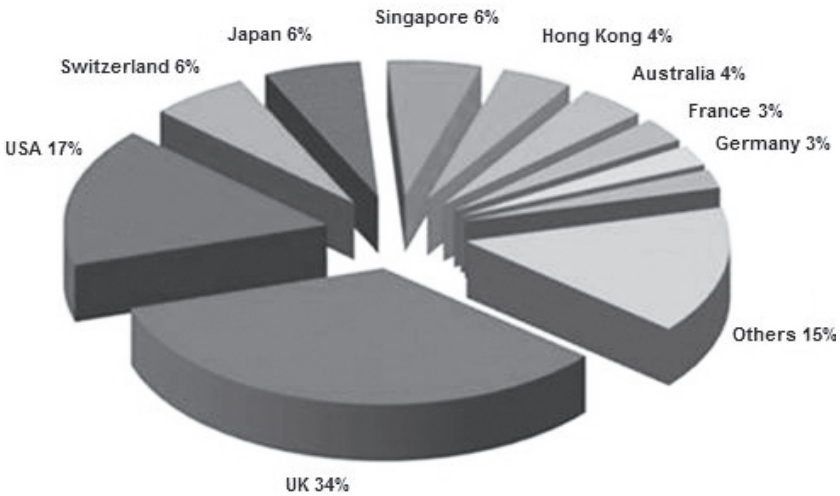
Chart 3
Forex Market Concentration



Source: BIS-2007 Foreign Exchange Triennial Bank Survey.

roughly 75% of the worldwide Foreign Exchange (FX) market share. Market opens on Sundays at about 5 PM EST, when New Zealand and Australian banks open; liquidity suddenly drops on Fridays at 5 PM EST as US banks close. The market remains open 24 hours a day but presenting a typical intraday and weekly seasonality well known in the academic community (i.e. Guençay et al., 2001). In the 80's the market was exclusively reserved to banks and financial companies as well as institutional traders, being the usual trade size in the order of 5-10 million USD. IT (Information technologies) evolution such as STP (straight though processing), Internet, as well as the entrance of new participants, lowered, the entry barriers in the 90's now being a market accessible at the retail level with competitive transaction costs.

The bibliographic research conducted (details further) reveals that releases have significant impact over exchange rates, volatilities and the number of quotes per unit of time (also known as tick frequency). News is defined in the bibliography (Parker, 2007) as the difference between market expectations and actual figures communicated during the data release. We will adopt this definition throughout this paper.

For relevant data releases news severely impact exchange rates thus creating risks for those who stay in the market during the announcement. Systematic traders such as high frequency/quantitative traders mostly rely on technical analysis tools enhanced by quantitative methodologies/technology. Technical analysis (as well as quantitative analysis) typically rely on past historical prices and volume data (where available) in order to generate forecasts and/or trading signals which form part of their alpha models. Data releases sometimes present extreme events; due to the short, rare and intense nature of these events, it is unlikely that their models hold true during releases leading to what it is known as model risk.

Unlike Black Swans – term coined by Nassim N. Taleb in his book *The Black Swan* (Zwick, 2007) –, data releases present one unique nature: they are scheduled beforehand; hence market participants may decide whether they either want to be in the market or hedge/offset their positions. Of course the variable

"news" presents a stochastic behavior (i.e. getting out of the market minutes before a data release may lead to a cost (at least the spread and/or commission) and there is no guarantee that news will finally occur), but for the most part releases are precisely scheduled and publicly known in advance. Of course events such as Sep11th terrorist attacks, or unscheduled data releases made available during speeches may also have extreme impacts but they are part of the risks of being in the market (and under such circumstances they could perfectly be called "Black Swans"). FX being the most liquid market available, during data releases participants become exposed to certain risks such as (but not limited to):

- Market Risk (adverse price excursion).
- Liquidity risk (wider spreads / illiquidity due to fast price moves / lack of dealable prices due to the effect of quote filtering algorithms).
- Model risk – quantitative/technical models based on historical patterns/data affected by fundamental noise/expectations.
- Lack of a "consensus price" during the price discovery process and OTC distributed market nature.
- Technological risk (execution delays due to server transaction capacity exceeded as a result of crowded order books, network delays due to intense traffic, stop/limit orders price targets being hit, etc).
- Magnified arbitrage opportunities/risks.
- Other risks such as incorrect quotations / bank re-quotes, adverse post-trade discretionary adjustments.

G-7 currencies not only present a liquid market but also data releases are properly scheduled and calendars are easily available for free at multiple websites as opposed to emerging market currencies (exotic pairs). Another advantage of G-7 countries is the lack of information leakage due to the procedures their governments/central banks put in place in order to ensure simultaneous data diffusion/press releases. These are enhanced by sophisticated legal frameworks which enforce inside information trading/leakage.

Market participants roughly have the same information simultaneously (discarding latency trading technologies implemented by high frequency niche players), hence market participants can only speculate trying to anticipate how the figures may look like once released based on publicly available information.

Global calendars present a description of the releases/scheduled events, usually containing data such as country, scheduled time and date, the type of data/indicator. When available the "consensus estimate" as well as the previous period figure is typically presented. On an ex-post basis some calendars also include the actual released indicator value. For the sake of this paper we will use EST (New York time) since the US is by far the country which presented most of the available data releases. In addition to it both quotes and calendars are in the same format which simplifies the database join between both data sources, disregarding daylight saving time changes.

2. Previous research and theoretical framework

One of the articles which motivated this research was a hedge fund manager interview published at Futures Magazine named: "Capricorn FX; Tested Methods That Work" (Zwick, 2007). The technical-analysis based fund Management state that they avoid being in the market during major data releases due to the increase in volatility associated during such events (higher risks) as well as evidencing that technically-based systems (which mainly rely on past historical quote information) do not perform well as a forecasting tool during such particular moments. They summarize their trading experience during releases in a very graphic way stating that "it's like flipping a coin". Technically-based systems (as well as quant ones) typically suffer during data releases

due to fundamental and irrational noise which may not be contained in past prices as well as being exposed to the previously mentioned risks. Given that closing or hedging existing open positions imply a cost (spreads, commissions, liquidity, lost trading opportunities [opportunity costs], etc.), practitioners (mainly risk managers, traders, hedge fund managers) may be attracted by having an "indicator roadmap" in order to determine the relevance of different data releases to decide whether they should stay or not in the market during a given release.

Our main driver for this research is to supply the academic and trading community with a reliable source of information (not available from freely available sources) to serve as a basis for further research as well as aiding hedge fund managers /market practitioners in their decision-making process.

Balduzzi, Elton & Green (1998) analyzed the impact of announcements in the bond markets over price, volumes and bid-ask spreads. As a result of using high frequency data, they were able to determine which indicators had the major impacts over price and traded volumes. They also outline that news effects on the cited variables take place in less than one minute after the announcement. They also conclude that spreads rapidly widen (same behavior with volatility) after the announcement returning to pre-release figures between 5-15 minutes after the announcement.

Eddelbuttel & McCurdy (1998) studied the impact of data releases over the Dollar-Deutsche Mark using 1-hour intervals. They concluded that there is a significant relationship between volatility and data release frequencies.

Andersen, Bollerslev, Diebold & Vega (2003) used 5-minute quote data for a period of six years for the Deutsche Mark, UK Pound, Japanese Yen, Swiss Franc, and the Euro in an effort to model the surprise impact (news) of economic indicators over the currency exchange rates. These authors found that markets react in an asymmetric form; that is that "bad news" typically presents higher impacts (overshoot) than "good news". They defined bad news as those published twice in a row below consensus expectations. It should be noted that in this research, the authors used a more extensive dataset, not only in terms of currencies, but also in terms of indicators and time frame, resulting an insightful paper. They also conclude that releases which contain a news component have an immediate effect over the quote conditional mean, while variance adjustments present longer-term gradual adjustments.

Andersen, Bollerslev, Diebold & Vega (2007) studied the response of US, British and German bonds as well as stocks to macroeconomic announcements. For each of the markets they used high frequency return data. They found that for similar instruments markets react in different ways, depending on the overall economy status. They conclude that the news (or surprise) component in data releases create jumps in the conditional price mean. Their results contradict other papers stating that price changes in these markets depended mostly from private information and contagion effects than from public information and data releases.

Bauwens, Omranen, Giot (2003) analyzed the impact of nine scheduled and unscheduled announcements over the EUR/USD volatility. They stress the impact of such announcements over the FX volatility as well as focusing on the increase in volatility, instants before the data release particularly on scheduled releases. They suggest that these moments are seen to the eyes of speculators as an "opportunity to anticipate what the market will do" and obtain some profits. They used 5-minute intervals covering the period May-Nov 2001.

Laakkonen (2004) focused on the news impact over the currency volatility, using previously scheduled releases both from the US and Europe for the EURUSD pair using 5-minute intervals. Results match those of previous researchers, being the volatility significantly affected by relevant releases. He also concludes that bad news affect more exchange rates than good ones. They also found that scheduled

releases without news (surprise component) also increase volatilities, but they suggest using longer historical datasets in order to confirm such result.

Chaboud, Chernenko, Howorka, Iyer, Liu, Wright (2004) analyzed the effects of news on rates and volumes based on EBS (Electronic Broking Service) data, which enriched quote data with traded volumes. They describe intraday impacts in volume and volatilities for EURUSD and USD/JPY. Results were in line with previous research, adding that news also increase trading volumes, presenting some persistence for a relatively long period of time. Even if the announcement match consensus expectations, traded volumes increase. These results agree with those of Laakonen (2004).

Ito, Hashimoto (2006) also used EBS data for analyzing USD/JPY and EURUSD pairs, finding that yields and volatility experience a U-shaped curve for the Tokyo and London participants but not for the ones from New York.

They observed that activity and volatility do not increase towards the end of business hours in the New York market, even on Fridays (ahead of weekend hours of non-trading). It is found that there exists a high positive correlation between volatility and activities and a negative correlation between volatility and the bid-ask spread. A negative correlation is observed between the number of deals and the width of bid-ask spread during business hours.

John C. Parker (2007) presents an excellent and insightful paper titled "The Impact of Economic News on Financial Markets", he also used high frequency data. He studied the impact before, during and after the releases over different markets. He analyzed US and European releases in an effort to determine which releases are actually relevant for each market. The paper is coherent with previous research in the fact that markets rapidly react to releases, but unlike some of them and due to the utilization of 1-minute returns he finds that markets usually react in less than one minute.

Laakkonnen & Lanne (2008) found that bad news present a higher impact than good news for US and European markets, also stressing that the effect they have actually depend on the crisis/prosperity statuses of the considered economies. Bad news during prosperity times present significantly higher impacts.

Bartolini, Goldberd & Sacarny (2008) focused on how economic releases affect the stock, bond and currency markets; stressing that important releases such as GDP advance, non-farm payrolls and the private manufacturing report result into significant and persistent market impact. The response observed at multiple assets is coherent in sign and magnitude; gaining value with news which translate into economic growth. They agree that daily data should be complemented with high frequency data in order to enhance analysis results.

Baumohl (2005) qualitatively classify (strictly ordinally such as minor, important, very important, etc) data releases based on their impact on exchange rates but without stating any academic support behind them. The book presents an interesting coverage of US data releases from a descriptive point of view. A summary of it can be found at Sánchez & Sapriza (2009).

In order to conduct a stricter research it is necessary to count with properly selected and cleansed quote data, as well as a reliable economic data release calendar with good data quality, in order to join both sources. None of the data sources was available to us when we started our research; the resulting datasets are properly cleaned, filtered, completed, systematically coded, resulting into highly reliable datasets. The efforts devoted to data management were considerable due to the poor data quality of available datasources.

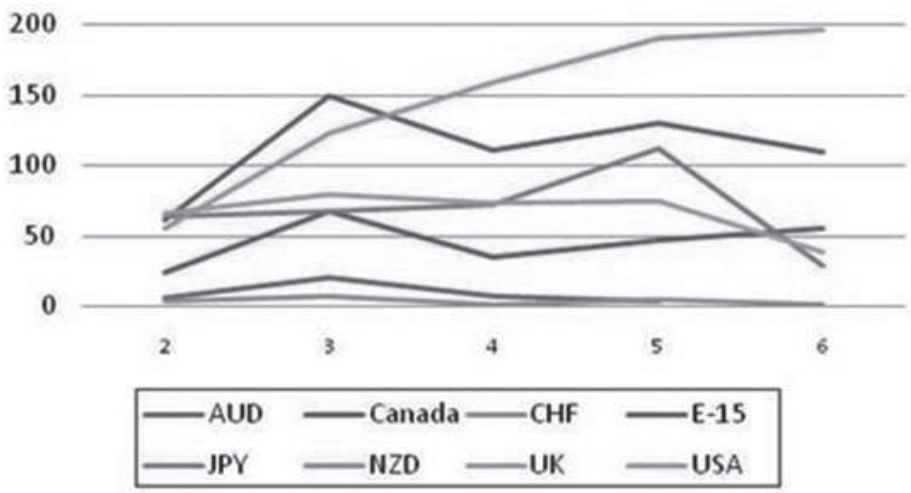
Based on our bibliographic research we noticed that few papers are focused on the impact of data releases on exchange rates using high frequency data and particularly no one extensively quantify/rate their impact based on the magnitude of their impact for G-7 currency pairs, being this the aim of our research.

3. Economic Data Release seasonality preliminary analysis

The following charts depict the amount of economic data releases present in the used global calendar (source: ‹www.forexnews.com›) by currency/country and broken down by weekday. Reference number 1 stands for Sundays, 2 for Mondays and so forth. Four variables were analyzed based on data from Gain Capital NY, the data processing details are described in the methodology section.

The number of quotation changes every 15 minutes (tick frequency), as a volatility/activity indicator. As evidenced from the literature reviewed, the presence of news typically increases volatilities. It should be stressed that the absence of valleys during data releases not necessarily means that such data release is not important or that it has no significant impact over exchange rates. A possible explanation could be that no news actually took place at such time (i.e. market expectations closely matched the actual figures released).

Chart 4
Economic Announcements by Weekday



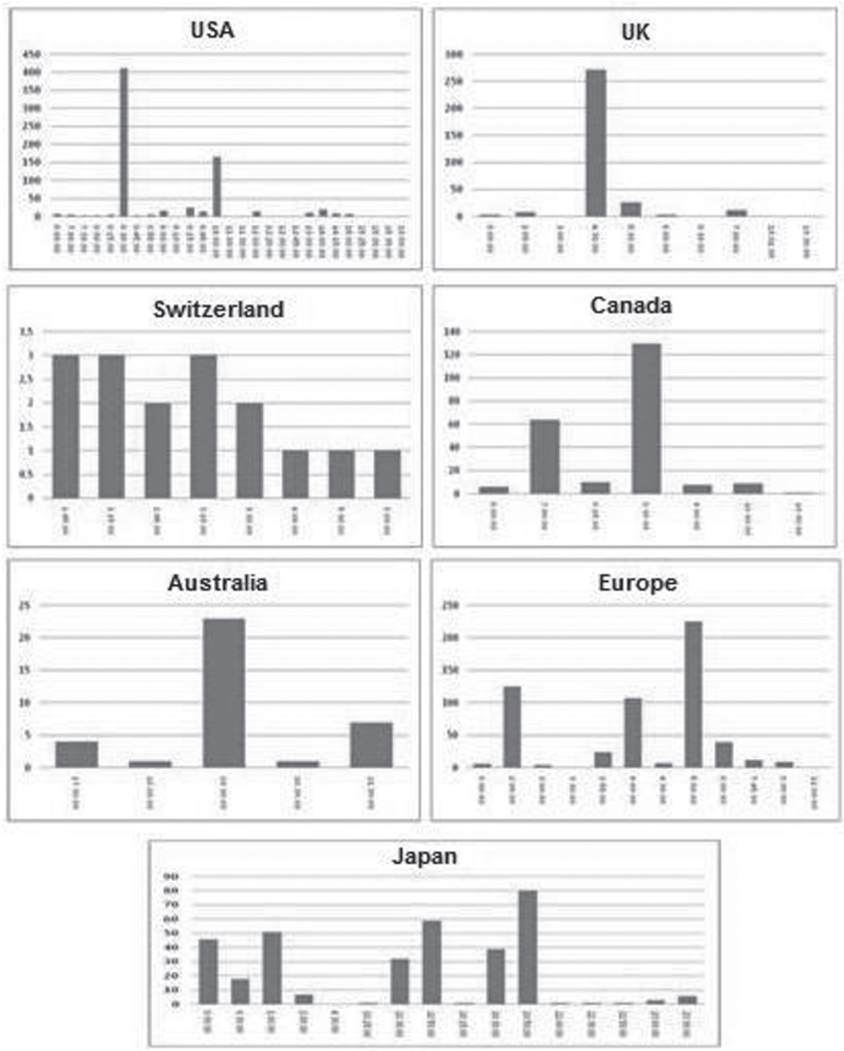
Source: Own indicator research database.

The opposite holds true if markets quantitatively prove to be affected by data releases (in the absence of external noise, other concurrent announcements or other effects), then the data release can be deemed to be classified as important or relevant. Of course causality is much harder to test and we have no other choice than to rely on empirical results based on samples.

As it can be appreciated in chart 4, Thursdays and Fridays concentrate most of the US data releases while for Europe, Canada and Australia data is typically disclosed on Tuesdays. Japan's announcements tend to cluster on Thursdays. We used EST (Eastern Standard Time) or New York time throughout the entire paper.

From exhibit Nr 1 we observe that most of the US announcements typically happen at 8:30 or 10:00. In the UK there is a clear concentration of events at 04:30. Unlike other countries where announcements tend to be released mostly at the same time of the day, Switzerland does not seem to have a preferred time for data delivery. The vast majority of Canada's announcements take place between 7:00 and 8:30. Europe presents three modes at 02:00, 04:00 and 5:00 being the latter the one which concentrates most of the releases. Finally Japan

Exhibit 1
Economic Announcements Hourly Concentratioin



Source: Own research database.

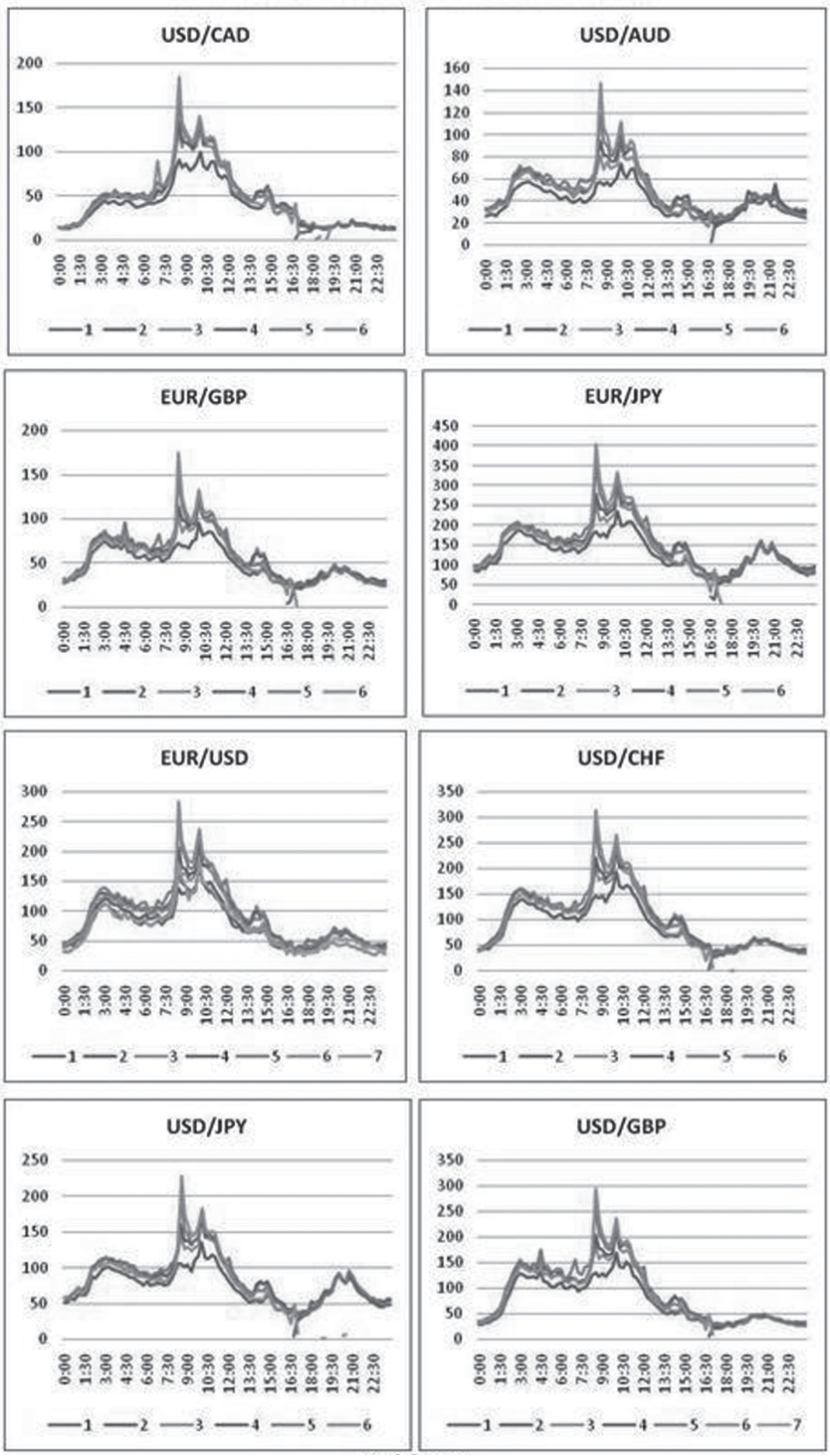
presents three different ranges, one between 00:00 and 01:00, another between 00:30 and 18:50 and the last one between 19:30 and 19:50.

3.1. Tick frequency

In exhibit Nr 2 we observe the average number of ticks per weekday. The horizontal axis indicates time while the vertical one displays tick frequency every 15-minute intervals. Reference number 1 stands for Sundays, 2 or Mondays and so forth.

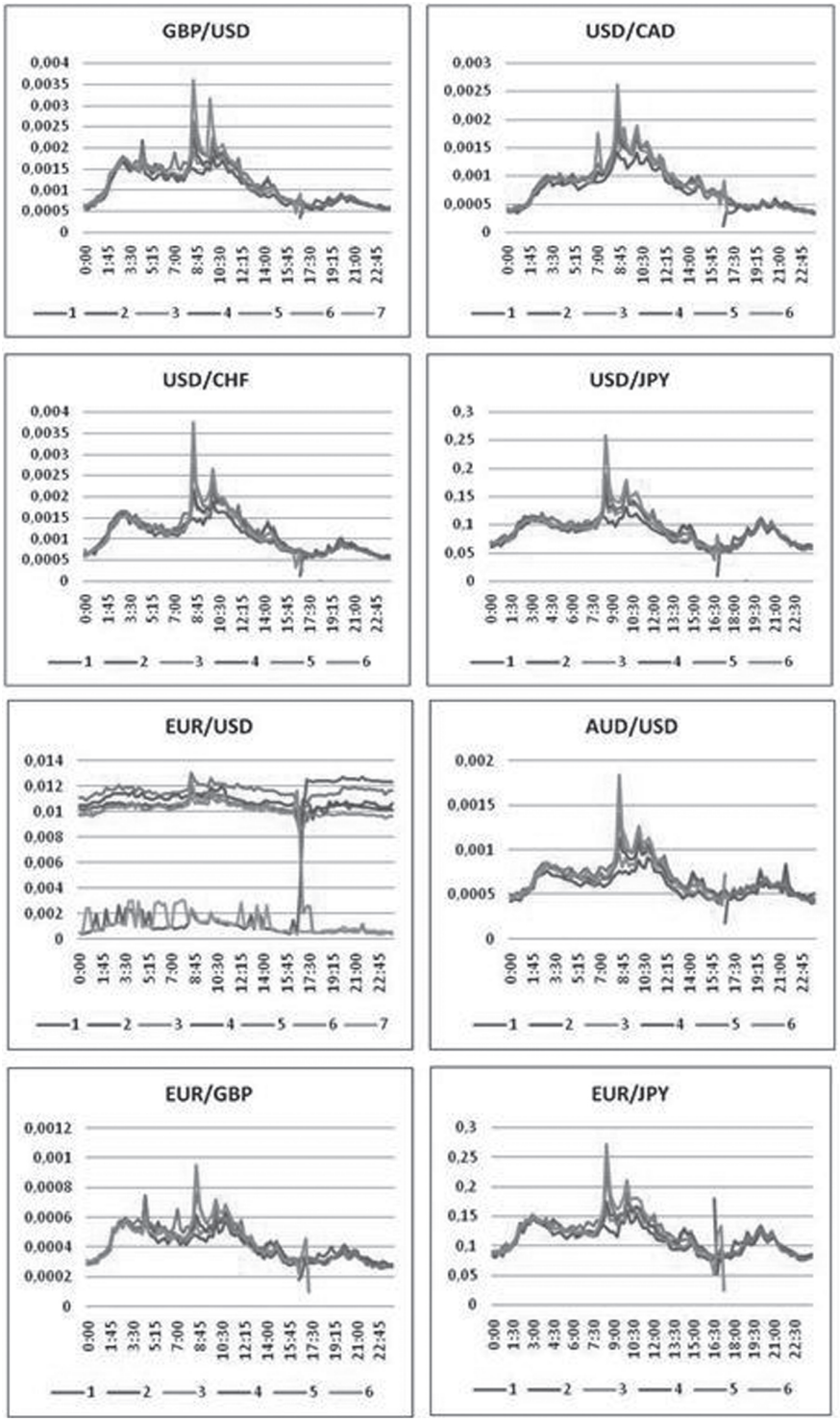
From exhibit Nr 2, an increase of the tick frequency can be observed after 01:00, this market activity increment is aligned with the occurrence of Japanese data releases at such time, increasing at 03:00, associated with the European announcements. Between 08:30 and 10:00 we can also observe the effect of US

Exhibit 2
Tick Frequency Weekly Average



Source: Own research.

Exhibit 3
High-low average – intraweek seasonality analysis



Source: Own research.

economic releases. After 10:00 activity starts decreasing until 17:00 where New York banks operation formally close. Between 18:00 and 22:30 Australian and Japanese announcements predominate

Regarding the different currency pairs, from exhibit Nr 2 particular behaviors can be observed. For example for pairs such as USD/JPY and EUR/JPY there is an increase in the tick frequency between 19:00 and 21:00 which is more concentrated than for other countries, in line with the previously discussed Japanese news release frequency plot.

The pair AUD/USD tick frequency surge at about 19:30 and 21:30, time range which data releases take place in Australia. For the Loonie (USD/CAD) the tick frequency spikes at 07:00 when some Canadian announcements become available. Similar considerations also apply for cable (GBP/USD) for Thursdays at 4:30 and 7:30, fully eclipsed with UK macro announcements.

3.2. High-low range average

Another variable included in our research is the 15-minute high-low gap, being the high the highest ask and the bid the lowest bid in the considered time span. It can be considered as a naïve volatility proxy, presenting the advantage of providing an idea of the potential maximum adverse price excursion for the considered interval.

The High-Low (H-L) range broken down by weekday and hour can be appreciated in exhibit Nr 3. Similar behaviors are observed when compared vis-à-vis with tick frequencies, except for the major pair EURUSD. Further investigations led to discard the EUR/USD dataset since data proved to contain wrong quotes and inconsistencies unlike the other datasets.

Given the similarity between H-L ranges and tick frequency, bivariate scatter plots were plotted and regression lines drawn given the linear relationships observed.

4. High-low average – intraweek seasonality analysis

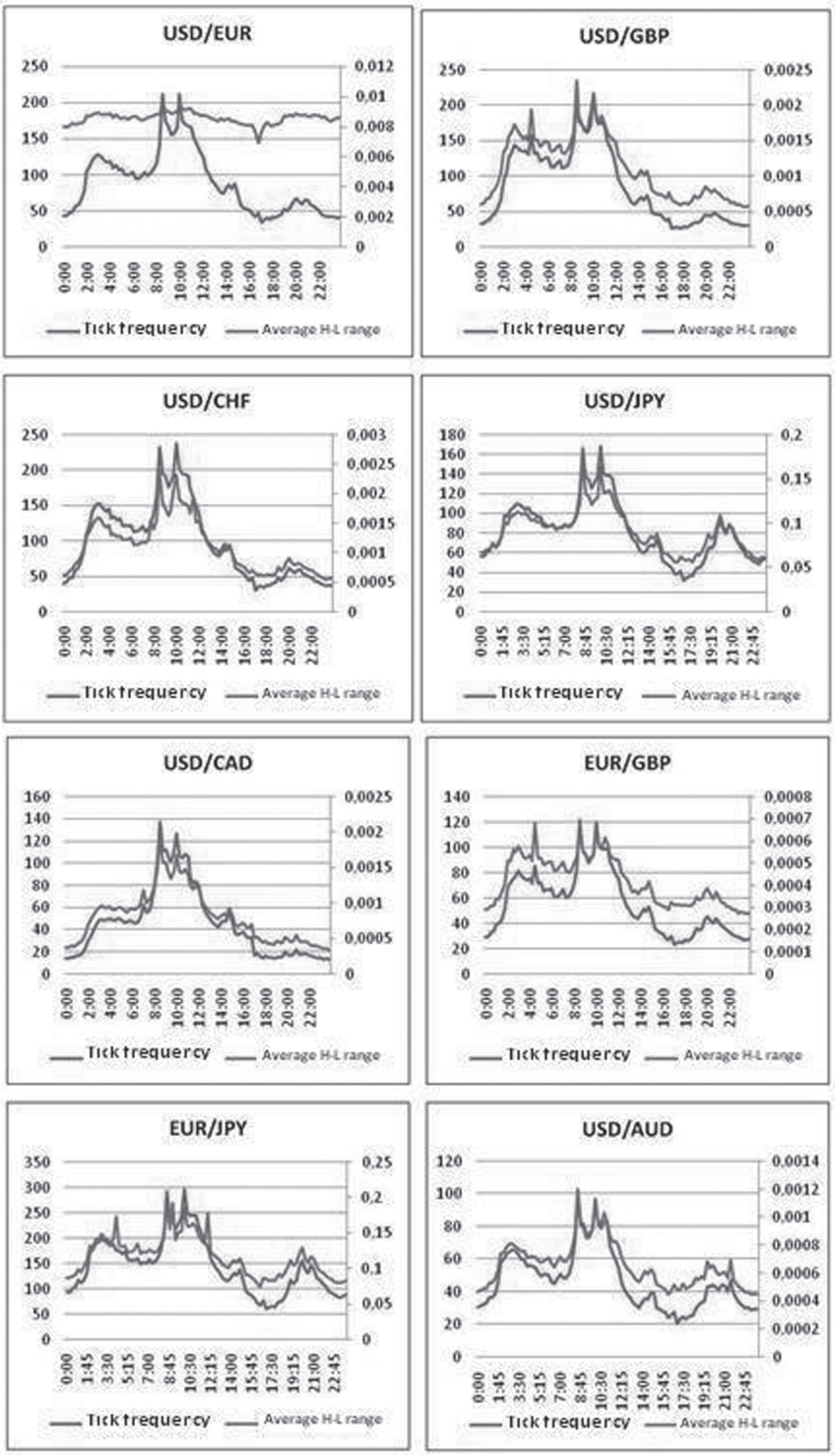
After visual inspection of exhibit Nr 3, there seems to be a clear relationship between the cited variable and the concentration of data releases. As an example on Fridays at 8:30 the highest High-low ranges (i.e. a volatility proxy) surges. Despite we are not stating that this happens every Friday (and actually that is the case) this surge seems to be related with important indicators issued by the US such as the Unemployment Data/Non-Farm Payrolls (widely followed by traders/practitioners). Similar behaviors can be observed on Sundays at 17:00 where peaks seem to be related with Australian announcements. For crosses such as EUR/GBP we can observe that they are rapidly arbitraged vs. their two major pairs in order to eliminate free-lunches, being coherent with the Efficient Market Hypothesis (EMH) despite at the tick level some inefficiency was spotted evidencing the semi-strong version of the EMH.

4.1. Tick frequency vs. H-L range average

To the naked eye both variables seem to be correlated due to their similarity and indeed they were as evidenced after charting both variables on scatter plots and looking at the Pearson's correlation coefficient R^2. This is consistent with the fact that the first order momentum distribution (based on tick data) rarely presents deviations of more than +/- 3 pips, hence wider H-L interval ranges necessarily imply higher tick frequencies in order to achieve the range as the frequency of large jumps or tick gaps is really scarce. Finally, we should stress that although large tick gaps/discontinuities are extremely rare, the first order momentum tick distribution is actually highly leptokurtic; presenting rare but impressively extreme events with occurrence probabilities far higher than those predicted by a normal distribution.

As stated before, both variables present joint behaviors (shared with data release

Exhibit 4
Tick frequency vs. H-L range average



Source: Own research.

publication times), which tend to cluster in three daily ranges, between 2:00 and 5:00, between 8:30 and 12:00 and the last one between 19:00 and 23:00. The second period represents the most active period (US data releases combined with Eurozone/North-American markets overlap). On the other hand, the period presenting the lowest figures for both variables takes place at about 17:00, time at which US markets, financial companies and banks «formally» close. It is not a coincidence that Gain Capital (the marked maker who supplied the data) performs its daily rollover adjustments and server maintenance/backup/housekeeping at such time.

The Pearson squared correlation coefficients yield the following results:

Exhibit 4a

Pair	Correlation
USD/ EUR	0,746302906
USD/AUD	0,97910904
USD/CAD	0,98592201
USD/JPY	0,98663589

Pair	Correlation
USD/CHF	0,98523838
USD/GBP	0,99065115
EUR/JPY	0,95187524
EUR/GBP	0,966759017

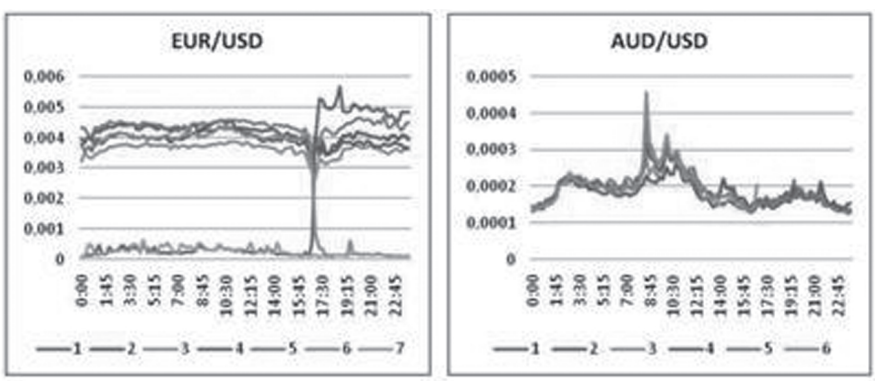
In general terms, the bivariate correlation coefficients are significant with the exception of EURUSD with an R^2 of approximately 0.75. After closer inspection of the dataset, several inconsistencies were spotted which led us to remove such data series from the analysis. The other datasets were also double-checked for the same inconsistencies (described under methodology) being all of them acceptable.

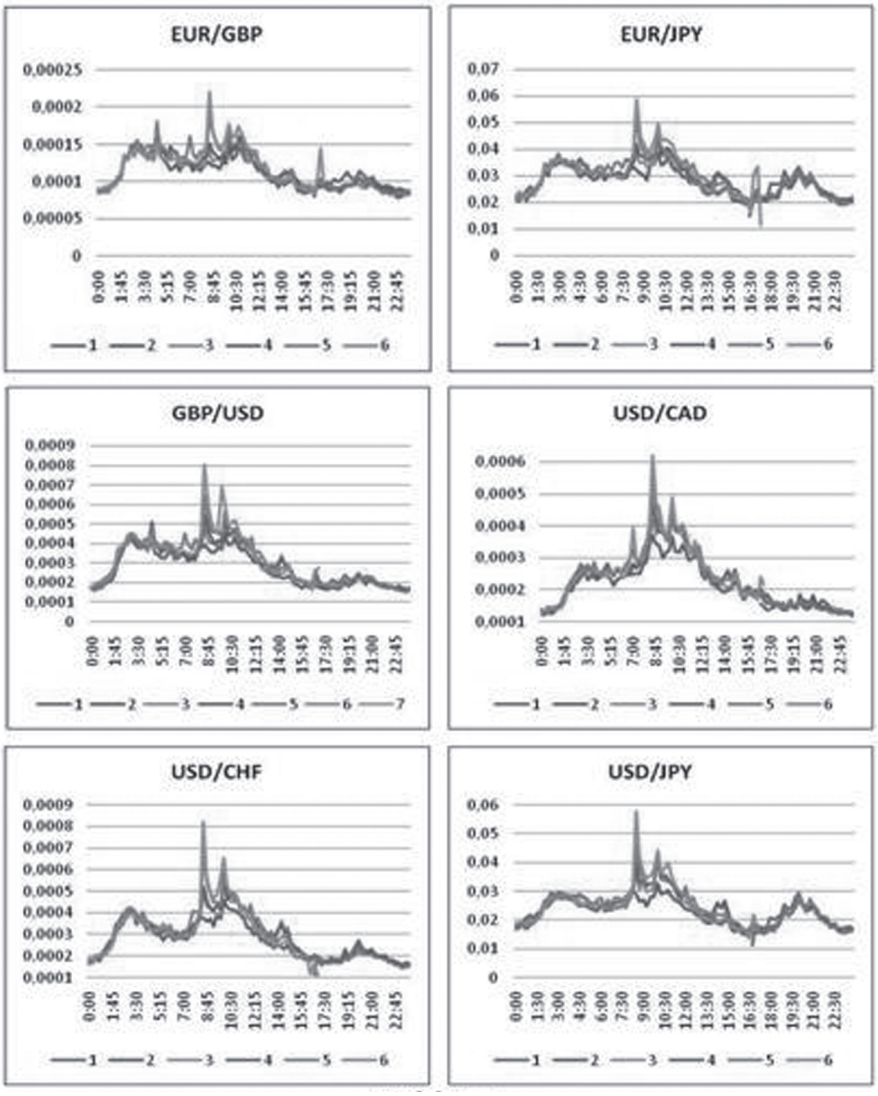
4.2. Interval bid-ask midpoint standard deviation by weekday

The 15-minute bid-ask midpoint standard deviation (for now on the "standard deviation") is presented in the exhibit Nr 5.

The behavior is analogous to that of the previous two variables (tick frequency and H-L range) since again we are in front of a volatility

Exhibit 5
Interval bid-ask midpoint standard deviation by weekday





Source: Own research.

proxy (similar to the H-L range) and by transitivity (given the linear relationship empirically observed) it is also expected to be correlated with the tick frequency too.

5. Methodology

We used high frequency (tick-by-tick historical data supplied by Gain Capital NY; a retail FX market-making firm which also operates with CTAs/small hedge funds. We covered the period 02-Jan-2003 to 27-Jun-2008 with over 120 million quotes for eight currency pairs loaded into the database, matched, filtered, checked for inconsistencies, mistakes and finally summarized by creating OHLC fixed-interval bars plus relevant stats.

Text files were loaded into an MS-SQL 2000 database, store procedures were developed in order to filter and organize the information.

- Records with Bid > Ask price were filtered as data proceeds from a marker-maker.
- Quotes between Fridays at 17:00 and Sundays at 17:00 were removed as the market is formally closed during such period.

Exhibit 5a

Pair	Correlation
USD/EUR	0,58253581
USD/AUD	0,96759645
USD/CAD	0,98463686
USD/JPY	0,98355029

Pair	Correlation
USD/CHF	0,9895473
USD/GBP	0,98936597
EUR/JPY	0,97076149
EUR/GBP	0,95907593

- Time stamp consistency – different formats were converted into a single one and quotes verified versus preceding and sub-seeding time series. When inconsistencies were detected, data was filtered (eliminated from our research).
- Data was checked for duplicates as some input files were partially overlapped, dupes were removed in order to avoid miscalculation of tick frequencies.
- Consecutive quotes with the same bid and ask were eliminated being a tick defined as a price change. This decision was taken since Gain Capital NY used to store each quote and timestamp before 2003 moving to this model after it, probably due to database storage capacity reasons.
- Data before 2003 was discarded in order to avoid possible sampling biases as for some currencies and periods data was incomplete in a semi-periodic form.
- Single ticks presenting significant departures vs. 10-tick moving averages in the absence of data releases or several standard deviations away were eliminated (i.e. decimal quoting errors, incorrect prices/time-stamps).
- After filtering OHLC (Open High Low Close) fixed-interval bars were created for daily, minute, 5-min, 15-min and 30-min respectively, in an effort to summarize the information for simplicity.
- Once converted to 15-min fixed interval OHLC bars, the last record from each Friday, as well as the first one from each Sunday was discarded in order to get rid of weekend gaps affecting variables such as ATR (described later).
- For each period the number of ticks (volume/market activity proxy), the average standard deviation of the bid-ask midpoint (volatility indicator) and the High-Low range (volatility proxy) were calculated.
- The ATR (Average True Range) was also included as it is an easy-to-calculate volatility indicator based on OHLC, taking into account the close of the previous bar which may be an advantage if the market reacts on the first tick after the exact release time. The ATR was introduced by the technician Welles Wilder in his book "New Concepts in Technical Trading Systems" (Wilder, 1978).

It is a simple way to estimate volatility from coarser granularity OHLC bars, when higher-frequency data is unavailable. It is defined as the maximum between:

$$\text{Average True Range} = \max(\text{high-close}_{prev}, \text{close}_{prev}\text{-low}, \text{high-low})$$

As it can be seen, gaps between the close and extremes in adjacent bars are considered, which is good in cases where market response is extremely fast after the release. In order to facilitate the analysis, separate fields for year, month, day, hour, minute, weekday (1[Sunday]…7[Saturday]) were created.

5.1. Economic data release calendar

The data used to populate the calendar was downloaded from the website ‹www.forexnews.com›, as well as other sources (mostly for validation purposes) such as Trader Forex, ‹www.traderforex.eu/es› and the National Bureau of Economic Research, ‹www.nber.org/releases›.

The calendar contains the following fields: date (dd/mm/yyyy), release time (hh/mm), country, currency or announcement zone, release description field, previous release value, consensus expectation (forecast) and lastly the actual release figure (updated on an ex-post basis of course).

Several data quality issues were faced during the preparation of this information.

Country names were not unique, there were synonyms, capitalized or not or even mistyped (for example US, USA, USD, or Canada, CAD or E-15, Europe, EUR, Eurozone, eurozone, eurzne, etc) – manual as well as ordinary text-mining techniques were used to improve the data-source quality, remove invalid characters, separate tokens, etc. European countries were coded as E-15, synonyms were also removed.

Calendar contents were validated with the aid of the Bernard Baumohl's book "The Secrets of Economic Indicators, Hidden Clues to Future Economic Trends and Investments Opportunities" (Baumohl, 2005), where a large table of US indicators was compiled including periodicity, release time, etc. Non-US data was similarly validated with the aid of Picker, Anne Dolganos's book "International Economic Indicators and Central Banks" (Picker, 2007). Missing calendar entries were inserted; data incorrectly coded under a different country or data release indicator was updated, etc.

Each of the indicators was systematically coded with a four-digit number. Codes beginning with 1000 and 2000 were reserved for US announcements, 4000 for Swiss, 9000 for the UK, 8000 European Union, 7000 Japan, 6000 Canada and finally 5000 for Australia. For special cases such as market holidays, speeches or those releases which presented difficulties were isolated with the code 9999. Some announcements were unable to be coded due to multiple reasons, for example lack of reliable/consistent data, lack of frequency (e.g. reported just for a single time or few observations)

Indicator units were another of the difficulties encountered, being used to validate results/spotting mistakes in data, when for example an unemployment rate was expressed in billion currency units.

Another verification included making sure that all the indicator series were complete (i.e. 12 monthly indicator releases/year, etc). The process was very tedious as some indicators are released on a given specific date while others have certain rules (for example the US Non-Farm Payrolls (NFP) are released the first Friday of every month at 8:30 EST as long as it is does not fall within the first 2 days of the month since previous-month data needs to be gathered/processed by the Bureau of Labor Statistics).

Once coded, the indicators needed to be checked for interferences as some are typically released concurrently (e.g. US NFP and the Unemployment Rate) or lower-frequency indicators (such as the US GDP (quarterly released), is published exactly at the same time as the employment data (e.g. Non-Farm Payrolls published on a monthly basis) thus overlapping in March, June, Sep & Dec. In order to determine interferences, if two indicators overlap within a 10-minute window they were specially labeled and interferences were tracked in order to be able to isolate the effect of individual indicators whenever possible. In some cases it proved to be impossible to analyze some indicators separately as they always overlap, so they were studied together, using a common code. Quarterly indicators overlapping with higher frequency indicators (e.g. monthly) had to be unfortunately removed from the analysis (e.g. US GDP) and the overlapping months of the other indicator were also discarded, keeping just the non-end-of-quarter months for analysis purposes. A boolean field was created for the com-

bination indicator/datetime with the purpose of filtering isolated (0) from those indicators which presented interferences (1).

Once both data sources (market data and the calendar) were clean and processed, they were joined into a single one and for each isolated indicator two samples were prepared. The first one contained periods affected by each indicator in isolation while the second included all the same monthly week number, weekday, and at the same time without the effect of any indicator, in order to account for seasonality effects. For variables under research, a Fisher's variance homogeneity test was carried out. Based on its result a Student's T two-tailed, two-mean hypothesis test was performed in order to compare each variable with and without the effect of the considered indicator as follows:

$$Ho: \mu_{\text{without indicator}} = \mu_{\text{with indicator}}$$

$$Ha: \mu_{\text{without indicator}} \text{ </> } \mu_{\text{with indicator}}$$

A significance level (α) of 5% was used for carrying out the tests.

6. Experimental Results and Discussion

Seven currency pairs, with over 100 million ticks covering the timeframe Jan/2003 to Jun/2008 were covered. Four variables were studied (tick frequency, interval H-L range, ATR, AVERAGE (AVG spread) for 15-minute intervals, comparing with the aid of two-mean two-tailed hypothesis tests whether the announcement had or not a statistically significant effect at the 5% significance level.

Results were grouped by release issuing country, ranking indicators by the Student's T test p-value results; we consider a significance level of 5% as tests threshold value. Announcements were ranked based on p-values derived from the Student's t-test (lowest figures first) for the ATR variable. An interesting observation is that in general terms the announcement ranking order holds for the other three variables under research. For the sake of this research indicator and announcement are considered synonyms.

In an effort to summarize results, tables were created containing:

- Announcement name
- Indicator code
- Indicator country
- Sample size presenting announcements
- Sample size without announcements
- Fisher's F-test result
- Student's t-test
- Student's t-test result based on a 5% significance level.

For the sake of brevity (and due to paper extension constraints) only the results table for Australia will be presented on this paper. Tables like the previous one are available for each of the studied countries, interested readers may either refer to Sánchez & Sapriza (2009) for additional details or contact the authors.

6.1. USA

As it can be derived from table Nr 1, 23 out of a total of 30 US announcements proved to be statistically significant at the significance level considered for the ATR variable. Analogously, 25 out of 30 tests yielded statistically significant results for the tick variable frequency. Only 11 and 20 indicators presented statistically significant effects on average interval spreads and interval tick quote standard deviation respectively.

For those announcements for which no evidence was found in order to reject the null hypothesis, it cannot be concluded that they are not important or that they present no effects over the studied variables. Either the lack of news at the announcements or a reduced fraction of them in the samples may, for example, have caused the tests to output the abovementioned results. Larger samples or even samples taken at different periods may lead to different results; what is true is that if an indicator yielded statistically significant effects over the considered variables; we can rely on

it (naturally assuming that no other external noise is present). Our methodology attempted to isolate any effect of other indicators which may flaw our research conclusions.

The fact of having considered a six-year period probably may had limited in some case the sample size for some indicator presenting lower release frequencies (e.g. quarterly). FOMC (Federal Open Market Committee) interest rate data releases were found to be the most influential ones, being in line with what we expected due to its importance in the exchange rate determination. In overall terms US releases presented a significant impact over exchange rate volatility (ATR and bid-ask midpoint standard deviation) as well as over activity levels (tick frequency). Mixed results were observed for spreads, which lead us to believe that Gain Capital NY may determine retail market-making spreads on a discretionary basis rather than as an exogenous market input.

6.2. Australia

As derived from the following table, four out of six indicators significantly affected volatilities (ATR and midpoint standard deviation).

For tick frequency all the indicators proved to have statistically significant effects. Measuring the effect in terms of the Student's t-test p-value magnitude, the CPI was the most influential indicator on volatilities while interest rate announcements were the most important ones over tick frequencies. Unemployment and GDP also presented important effects over volatilities and tick frequency as expected. On the other hand, retail sales (and to our surprise the trade balance) did not presented significant effects over the variables under research. With the exception of interest rate announcements, no other releases statistically affected retail market-maker spreads.

6.3. Japan

Volatility is remarkably affected by Machinery Orders, GDP and Industrial Output. This is not surprising given the industrial development of this country which accounts for an important portion of its GDP. One striking observation was the mixed behavior observed for the unemployment rate; significant for ATR but not for tick frequency.

Unlike to what was observed in the US, the Consumer Confidence Index (CCI) seems not be considered by market participants in Japan as it neither affected volatilities nor tick frequencies.

Regarding spreads, results match the observed patterns in the sense that they do not seem to be affected by releases in a systematic way as observed for the other variables. Only the Consumer Confidence Index and the Merchandise Trade Balance yielded significant effects on spreads, which combined with the results of CCI over volatilities and spreads reinforce our hypothesis that Gain Capital NY may determine spreads on a managerial/discretionary basis rather than as a response to market exogenous variables (i.e. volatility).

6.4. United Kingdom

Unlike other countries/pairs there is no statistical evidence to reject the null hypotheses for the unemployment rate for any of the variables. Despite bibliographic research has been conducted in order to find an explanation for this unusual behavior, results were unfruitful. Perhaps its proximity with the interest rate decision (released two days before the unemployment rate report) may relief attention from market participants as unemployment data perhaps may be known as a known variable to the Royal Bank of England board prior to the interest rate decision. Another possibility could be the lack of news or lack of widely accepted consensus forecasts but the real explanation is honestly ignored.

Interest rate announcements were the ones which presented the highest significance both for volatility and tick frequency among pairs, with an impressive p-value. Following interest rate announcements; retail sales, industrial output and manufacturing output (concurrently

Australia Results

					ATR		
Indicator	Indicator	Country	N1 (w/o announcement)	N2 (w/ announcement)	F-FISHER	T-STUDENT	Conclusion
Consumer Prices Index	5003	Australia	95	12	1,3E-01	2,1E-03	REJECT Ho
Employment	5002	Australia	155	30	4,7E-01	4,8E-02	REJECT Ho
Bank interest rate	5007	Australia	87	78	2,7E-03	3,6E-04	REJECT Ho
Gross Dosmestic Product	5000	Australia	23	10	4,3E-01	6,9E-03	REJECT Ho
Trade Balance	5005	Australia	155	17	4,8E-02	7,9E-02	ACCEPT Ho
Retail sales	5006	Australia	362	10	3,3E-01	1,1E-01	ACCEPT Ho

						Ticks	
Indicator	Indicator	Country	N1 (w/o announcement)	N2 (w/ announcement)	F-FISHER	T-STUDENT	Conclusion
Consumer Prices Index	5003	Australia	95	12	2,6E-04	8,0E-04	REJECT Ho
Employment	5002	Australia	155	30	9,2E-01	1,4E-02	REJECT Ho
Bank interest rate	5007	Australia	87	78	6,3E-09	2,1E-26	REJECT Ho
Gross Dosmestic Product	5000	Australia	23	10	1,9E-01	1,0E-03	REJECT Ho
Trade Balance	5005	Australia	155	17	5,2E-01	2,4E-03	REJECT Ho
Retail sales	5006	Australia	362	10	2,5E-01	4,2E-02	REJECT Ho

						Avg_spread	
Indicator	Indicator	Country	N1 (w/o announcement)	N2 (w/ announcement)	F-FISHER	T-STUDENT	Conclusion
Consumer Prices Index	5003	Australia	95	12	9,2E-01	5,8E-01	ACCEPT Ho
Employment	5002	Australia	155	30	8,5E-01	5,7E-01	ACCEPT Ho
Bank interest rate	5007	Australia	87	78	1,7E-01	4,4E-02	REJECT Ho
Gross Dosmestic Product	5000	Australia	23	10	9,3E-01	7,5E-01	ACCEPT Ho
Trade Balance	5005	Australia	155	17	8,7E-01	6,4E-01	ACCEPT Ho
Retail sales	5006	Australia	362	10	5,2E-04	6,1E-01	ACCEPT Ho

					Stddev_mid		
Indicator	Indicator	Country	N1 (w/o announcement)	N2 (w/ announcement)	F-FISHER	T-STUDENT	Conclusion
Consumer Prices Index	5003	Australia	95	12	3,6E-03	1,4E-03	REJECT Ho
Employment	5002	Australia	155	30	3,9E-01	4,0E-04	REJECT Ho
Bank interest rate	5007	Australia	87	78	7,3E-09	3,2E-04	REJECT Ho
Gross Dosmestic Product	5000	Australia	23	10	4,6E-01	6,0E-03	REJECT Ho
Trade Balance	5005	Australia	155	17	1,5E-01	1,2E-01	ACCEPT Ho
Retail sales	5006	Australia	362	10	5,8E-01	1,9E-01	ACCEPT Ho

delivered) turned out to be the most influential announcements in the UK.

Retail sales was the indicator which presented the lowest p-value among UK indicators, being statistically significant even for the average spread, behavior also observed for the US. Ultimately overall table results are in line with what was expectable to us in terms of indicator relevance, presenting most of them statistically significant effects over volatility variables and tick frequency.

6.5. Canada

Eight out of nine announcements proved to have statistically significant effects over the ATR and tick frequency. The CPI presented highly significant figures, followed by the

Employment stats, interest rate decisions and retail sales. These indicators are typically announced between 07:00 and 09:00, being similar to what was observed before the most important time span for both Canadian news as well as tick frequency for the CAD. Again the Loonie shares common behaviors with the other studied currencies, being interest rates and unemployment data the most relevant ones as expected. The average spread confirms the observations outlined at other pairs suggesting that the market-maker seems to determine spreads discretionally.

6.6. European Union

For the European Union the only data release which presented statistically significant effect over the ATR and tick frequency was the interest rate monetary decision. Perhaps a possible explanation could be that no single-country indicator is as relevant as aggregate European indicators/data (of course interest rates are extremely important from an economic fundamental standpoint). Another possible explanation could be the lack of an exact and sustained publishing date and time.

7. Conclusions

The following four tables summarize the main research results over the four studied variables (ATR, tick frequency, average spread and tick standard deviation). The dark grey cells indicate releases whose two mean student t-test p-values are significant at the 5% significance level while the clear grey ones point out those where the null hypothesis is accepted.

In light of the results found the following points can be outlined:

- A set of tables with clean and validated data on multiple indicators was created, serving as start point for future research.
  - Given the lack of significance for the hypothesis tests for the average spread, it leads us to think that Gain Capital NY may probably set their spreads on a discretionary basis instead of being a market-maker exogenous variable such as the bid-ask midpoint, etc.
  - For the Average True Range (ATR), bid-ask midpoint standard deviation and tick frequency the vast majority of the data releases proved to have statistically significant effects at the significance level considered.
  - Labor market stats proved to be one of the most important indicators for most of the studied currency pairs.
- Most of the high-impact on few indicators are released between 08:30 and 10:00, driven by US releases.
- The risk Management practice of closing/offsetting open market positions minutes before certain data releases put in place by certain hedge fund managers (e.g. Capricorn FX) is supported by our results. Since most of the data releases are precisely scheduled in advance, the manager could opt to be out in order to avoid unnecessary exposure to excessive volatility. Based on our research it cannot be derived from it that market predictability, resulting from technical or quantitative analysis techniques, is actually affected by these events (although it seem plausible) but the fact that traders who stay in the market during certain data release are exposed to an extreme volatility (market) risk. At the moment of the release, other risks also take place such as liquidity risk, slippage, re-quotes, incorrect quotations, model risk, technological risk (overloaded servers, delays in execution, crowded order books), post-trade bank adjustments, etc. It should be noted that tick frequencies during data releases can be several orders of magnitude higher vs. lack of them, ceteris paribus, pointing out possible explanations for the outlined technological risks when servers become undersized during such events.

Results 1

ATR	Canada	Australia	Japon	USA	UK	Europe
GDP	7,9E-03	6,9E-03	1,1E-04		4,9E-06	7,0E-02
CPI	2,9E-12	2,1E-07	1,7E-03	7,6E-04	6,8E-08	1,8E-01
Retail Sales	4,9E-08	1,1E-01	4,6E-03	4,0E-02	1,5E-15	3,1E-01
Bank Interest Rates	3,5E-08	3,6E-04	3,1E-02	2,2E-13	4,7E-17	1,5E-06
Housing Starts	2,2E-02		3,6E-01	6,0E-02		
Leading Indicators	3,4E-01		6,1E-01	2,3E-03		
Consumer Confident			9,2E-01	4,6E-04		
Employment situation	7,0E-12	4,8E-06	4,8E-02	8,0E-13	8,9E-01	3,7E-01
Trade Balance	1,7E-03	7,9E-02	6,0E-03		1,9E-07	9,0E-01
PPI				6,4E-04	1,2E-02	

Av Spread	Canada	Australia	Japon	USA	UK	Europe
GDP	4,9E-01	7,5E-01	8,4E-01		2,5E-01	8,4E-04
CPI	9,4E-02	5,8E-01	2,2E-01	3,2E-01	4,2E-01	9,9E-01
Retail Sales	8,7E-01	6,1E-01	9,2E-01	2,0E-06	4,1E-03	5,9E-01
Bank Interest Rates	5,0E-01	4,4E-02	2,6E-01	1,5E-01	3,4E-01	5,4E-01
Housing Starts	1,2E-02		2,9E-01	2,7E-01		
Leading Indicators	2,1E-01		6,1E-01	2,2E-01		
Consumer Confident			4,8E-03	9,2E-01		
Unemployment	7,4E-02	5,7E-01	8,0E-01	7,8E-02	4,9E-01	6,3E-01
Trade Balance	2,3E-01	6,4E-01	3,3E-04		3,6E-01	7,2E-02
PPI				6,7E-01	1,8E-01	

Ticks	Canada	Australia	Japon	USA	UK	Europe
GDP	2,3E-03	1,0E-03	5,2E-06		4,6E-07	1,9E-03
CPI	3,2E-16	8,0E-04	3,5E-03	4,3E-05	1,7E-18	9,8E-01
Retail Sales	6,4E-12	4,2E-02	1,1E-02	3,8E-02	1,8E-19	5,7E-01
Bank Interest Rates	2,6E-11	2,1E-30	4,7E-02	2,2E-16	9,2E-26	8,1E-07
Housing Starts	3,7E-04		6,5E-01	3,1E-03		
Leading Indicators	4,6E-01		8,6E-01	3,7E-09		
Consumer Confident			1,3E-01	1,4E-05		
Employment situation	2,2E-23	1,4E-06	2,1E-01	2,3E-18	9,7E-01	1,1E-01
Trade Balance	1,2E-08	2,4E-03	4,6E-03		7,3E-09	8,4E-01
PPI				4,8E-05	2,3E-03	

Stddev_mid	Canada	Australia	Japon	USA	UK	Europe
GDP	1,0E-09	6,0E-03	3,0E-04		2,3E-05	7,1E-02
CPI	1,7E-14	1,4E-03	1,9E-03	8,5E-04	2,2E-06	2,0E-01
Retail Sales	9,6E-08	1,9E-01	5,5E-02	4,0E-02	9,2E-18	3,8E-01
Bank Interest Rates	1,8E-09	3,2E-04	1,9E-01	3,4E-12	1,4E-18	7,3E-06
Housing Starts	8,6E-02		4,6E-01	1,0E-01		
Leading Indicators	1,9E-01		4,7E-01	1,0E-02		
Consumer Confidence			7,4E-01	6,3E-03		
Unemployment	5,1E-14	4,0E-08	1,2E-01	1,6E-10	6,8E-01	7,5E-01
Trade Balance	8,6E-03	1,2E-01	1,8E-02		3,8E-06	8,8E-01
PPI				1,1E-04	1,1E-02	

- Announcements present two remarkable properties: they are scheduled beforehand with precision (exact time and date in most of the cases) and (with the aid of this paper and other researcher's work) it is now possible for a hedge fund manager to determine whether to stay or not in the market considering our "catalog" of data releases. It should be stressed that closing/hedging open positions also imply trading costs.
- Finally the fact that any given indicator has not turned out to have statistically significant effects over the studied variables does not necessarily imply that it may not be important or that may not have significant effects in the future. It is based on a temporal limited sample and of course as a stochastic variable, no news (difference between consensus expectations and actual data released) could have been present in it.

Taking into account the research main strengths and weaknesses, we can summarize the following points as major strengths:

- The utilization of high frequency (tick) data presents significant advantages such as for example:
- Reduction of interferences between announcements to a lesser degree
- Lower noise levels or data contamination due to unscheduled extraordinary events.
- Since getting out of the market represents a cost (spreads, commissions, liquidity issues, opportunity costs), shorter intervals may aid managers in the decision-making process as opposed to coarser (i.e. hourly) intervals due to the increased precision.
- Unlike other authors which focused their efforts on a few indicators or limited to a single country, a wider spectrum of indicators and countries/currencies have been covered.

- Most of the bibliography present qualitative estimates for different indicators (i.e. Baumohl)[5] regarding their relative impact over exchange rates, this research shed light in quantifying such effects for the period under research (Jan2003-Jun2008) as well as determining the statistical significance of the impact of such indicators.
- Based on a strict methodology, a raw dirty data source has been turned into a high quality economic indicator and quotes database with data properly filtered, validated, codified, in a consistent time zone and even containing indicator interferences among releases. This information may become extremely valuable for both researchers and quant practitioners.
- On top of indicator interferences, intraday, weekly and monthly seasonality were taken into account when sampling data in order to perform each hypothesis testing, with reasonably large sample sizes.

On the other hand, the following issues were identified, reported and represent research topics to be addressed in future research efforts:

- As we worked with samples covering a certain time frame, statistical absence of evidence of the impact of a given indicator over exchange rates does not necessarily imply "evidence of no absence" of the abovementioned effects. Perhaps there were no news within a given sample, or the effect of an extreme event was diluted by a majority of releases lacking news thus leading us to conclude that there is no statistical evidence in order to reject the null hypothesis. We have not empirically analyzed this possibility being a suggested further research topic.
- Relevant announcements such as the US GDP and Trade Balance unfortunately have not been taken into account due to the overlapping interference with higher release frequency indicators.
- For indicators such as the US unemployment /NFP/labor data releases we had no other choice than analyzing them together as a single indicator as, although we have not attempted to prove causality in any of the cases, it is unlikely that it could be quantitatively attributed. Press and practitioners stress that NFP are the most significant one but quantitatively from our research we unfortunately cannot provide any confirmation.

Taking into account the abovementioned framework, the following items naturally emerge as suggestions for future research:

- Unlike other countries, the unemployment rate in UK and Europe did not proved to be significantly affect over the tick frequency and volatility, striking observations given the importance of such indicators over monetary policy decisions thus deserving further investigation.
- Local pre and post-release behavior of the variables under research on a high-frequency basis (temporal effects), volatility decay patterns relative to the type of indicator; speeches vs. data releases, etc.
- Determine relative country-weights for European releases.

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Economic Announcement Coding

Due to space constraints, tables, full datasets and calendars were not included in this paper; please contact the authors for dataset requests, questions and feedback. Such information is also available at the Uruguayan Catholic University under Sánchez y Sapriza (2009).