Are Hedging Successful at Risk Reduction? Some Evidence from European Nonfinancial Firms

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Abstract

We use a sample of 304 European firms traded in Euronext to investigate whether firms use risk management instruments for hedging or for speculative purposes. Using standard methodology, firstly, we test the relationship between firm value and financial risk exposures. We find evidence that sample firms' exhibit higher percentages of financial risk exposures when compared to previous studies.

Subsequently, we investigate the determinants of financial exposures. We argue that hedging policies affect the firm's financial risk exposure; however, we do not discard the fact that the magnitude of a firm's exposure to risks affects hedging activities. We find that hedging is significantly associated with financial price exposure, but only in the scope of exchange risk and commodity risk exposure. Our results are also consistent with the idea that financial risk exposure and hedging are endogenously related.

Key words: Foreign exchange rate, interest rate, commodity price, risk exposure, hedging.

EFM Classification: 450

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1. Motivation and overview

Over the last three decades we have assisted to an increase in the volatility of the prices of financial and nonfinancial assets. In face of this reality, risk management activities have become standard practices for firms facing financial risks. At first glance, this development seems to highlight the potential benefits perceived by corporate agents at the firm's value level. However, despite the current popularity of risk management, there is a large discussion in academic literature concerning the truthful contribution of risk management to firm value (e.g., Carter, Rogers, & Simkins, 2006; Jin & Jorion, 2006).

The vast majority of the existing empirical literature has attempted to show that the use of derivatives as a hedging mechanism can be value enhancing; initially, by trying to uncover which theory of hedging best describes firms' use of derivatives (e.g., Bartram, Brown, & Fehle, 2009; Mardsen & Prevost, 2005; Tufano, 1996); later, by testing directly the impact of risk management activities on firm value (e.g., Allayannis & Weston, 2001; Guay & Kothari, 2003; Jin & Jorion, 2006). Implicit to these tests has been the assumption that firms use derivatives solely for the purpose of hedging. However, despite firms' pronouncements in favour of derivatives use for hedging purposes, it is not clear whether this is the case. Indeed, hedging, by definition, will seek to reduce the level of risk to which a firm is exposed. On the other hand, when derivatives are used to take advantage of perceived market imperfections, they will increase risk.

The view that volatility of financial prices affects a firm's value and, therefore, the price of its stocks is generally recognized by economists, financial analysts and corporate managers. In this context, there is substantial the literature concerning nonfinancial firms that suggests that changes in financial prices (foreign exchange rate, interest rate and commodity prices) affect firm's value. However, these studies have met limited success in documenting significant financial price exposures. They focus mostly on foreign exchange exposures (e.g., Hagelin & Pramborg, 2004; He & Ng, 1998; Jorion, 1990) or (less often) on interest rate exposures (e.g., Bartram, 2002; Sweeney & Warga, 1986). In contrast, the impact of commodity price changes on corporations is analysed only in a few studies (e.g., Bartram, 2005; Tufano, 1998). Studies from authors such as Jorion (1990), Hagelin and Pramborg (2004) and Bartram (2005), among others, find that only a percentage of their sample firms show significant exposure to financial price risks.

A priori, if companies are exposed to financial price risks and if they use derivatives to manage one or more of those exposures, a change in the sensitivity of their stock returns to those risks would be evidence that the market reacts to risk management activities. Until

recently, little effort has been directed towards analysing whether firms are successful or not in reducing risk pertaining to financial price exposures when hedging instruments are used. To the best of our knowledge, the study from He and Ng (1998) is the first one to suggest that the extent of exchange rate exposure is determined by the firm's hedging activities. In line of this study, other recent works, such as the ones from Allayannis and Ofek (2001) and Hagelin and Pramborg (2004), documented a significant reduction in foreign exchange exposure sustained by the use of currency exchange derivatives. Subsequently, in a recent study, Bali, Hume and Martell (2007), based on a sample of firms of four selected industries, analyse simultaneously the three categories of risks and find that hedging with derivatives is only significantly related to commodity price exposure. Despite the fact that the majority of existing empirical literature relates to the implicit assumption that firms that do not use derivatives are not hedging, recent research also examines the association between exposure and proxies for firm's on-the-balance hedging activities (e.g., Allayannis, Ihrig, & Weston, 2001; Carter, Pantzalis, & Simkins, 2003; Hagelin & Pramborg, 2004; Williamson, 2001).

In this study we address the key issues mentioned above. Namely, we intend to analyse whether firms use risk management instruments for hedging or for speculative purposes. We use monthly returns of 304 firms listed in Euronext during the period from 2006-2008. The data from the four countries with stocks traded in Euronext – Belgium, France, The Netherlands and Portugal – are well adapted to the tests we propose to do. The economy of all four countries can be considered well industrialised and open, the capital market is considered generally unrestricted and trading partners are mainly in the same conditions.

We pursue Jorion (1990) and Allayannis and Ofek (2001) two stages procedure to investigate, firstly, the relationship between firm value and exchange risk, interest rate risk and commodity price risk factors, all together; and afterwards, the effect of hedging activities and firm's real operations on financial price exposures estimated in the first stage. As an alternative to standard derivative proxies used in previous studies, our proxy of hedging activities is a dummy variable that accounts simultaneously for the use/non-use of on-balance sheet and off-balance sheet hedging instruments by category of risk. Our primary assertion relies on the fact that hedging policies affect the firm's exposure to changes in financial price factors; however, we do not discard the fact that the magnitude of a firm's exposure to risks affects hedging decisions. Indeed, one of our contributions relies on the fact that we recognize financial price exposure and hedging as endogenously determined. As a result, in order to avoid spurious regression results, we develop a system of simultaneous equations and apply Seemingly Unrelated Regression (SUR) procedure.

This paper quantify the impact of the use of derivative and non-derivative instruments on financial price exposures, making use of a broader sample of nonfinancial firms across all industries. Besides, there are few published papers about hedging activities by means of data from Continental Europe, namely with data based on the new International Accounting Standards that require detailed reporting on derivatives,[3] and none that we know use data on a sample formed by the four selected countries. Furthermore, we are motivated by the lack of empirical evidence concerning the interrelationship between financial price exposures and hedging, which we believe is scarcely investigated and limited to the US (Carter *et al.*, 2003). In line with this, we believe that it will be useful to test this interrelationship in Continental Europe considering the three mainly categories of financial price risk and the broad array of hedging techniques reported by firms.

The remainder of the paper is organized into four more sections. Next section presents empirical evidence related to the financial price exposures, namely foreign exchange rate exposure, interest rate exposure and commodity price exposure and explores the determinants of these exposures. This is followed by the description of the sample and the methodology (section 3). Section 4 contains the empirical results. Finally, section 5 concludes the paper.

2. Empirical evidence on financial price exposures of nonfinancial firms

Financial risks for nonfinancial corporations consist – broadly defined – of unexpected changes in foreign exchange rates, interest rates and commodity prices. In this sense, financial price exposure can be defined as the influence of financial price changes on the future cash flows of the firm. Since firm value is represented by the present value of future cash flows, financial price exposure is the sensitivity of firm value to financial price changes. Initial research in this area analyses stock returns to provide empirical measures of corporate exposure to financial risks. Most of this research has been devoted to exchange rate exposure (e.g., Jorion, 1990; Williamson, 2001) and while some has tested for interest rate exposure (e.g., Bartram, 2002), this has been largely for financial firms (e.g., Oertmann, Rendu, & Zimmermann, 2000). Subsequent research investigates the effect of financial hedging in financial risk exposures, predominantly in foreign exchange exposure (e.g., He & Ng, 1998; Nguyen & Faff, 2003), and more recently a small number of studies examine also the ability of operational hedging to reduce risk exposures (e.g., Carter *et al.*, 2003). In Appendix A we present a detailed description of the reviewed paper surrounding this matter.

[3] International Accounting Standards 32 and 39 have been mandatory in European Community since 2005.

The focus of existing empirical exposure studies on foreign exchange rate risk has been justified with the argument that exchange rate risk represents a major source of risk, due to its higher volatility, when compared to other financial prices (Jorion, 1990). Nevertheless, a comparison of the standard deviations of various financial prices (exchange rate, interest rate and commodity price) reveals that in recent years interest rate and commodity price display even higher volatility than foreign exchange rate (Bartram, 2005).[4] Therefore, the impact of interest rate and commodity price changes on firm value can be classified as an important issue for corporate risk management.

2.1. Foreign exchange rate exposure

Dumas (1978) and Adler and Dumas (1980) define foreign exchange rate exposure as the effect of unanticipated exchange rate movements on firm value. Later, in a seminal paper, Adler and Dumas (1984) suggest that exchange rate can be estimated by the slope coefficient in a linear regression of the value of a firm on exchange rates. Moreover, Adler, Dumas and Simon (1986) suggest the use of stock returns and exchange rate changes in order to avoid statistical difficulties related to the stationarity of series. Thus, foreign exchange rate exposure can be measured through a simple time-series regression that considers the change in firm value (represented by stock returns) as the dependent variable and the exchange rate changes as the independent variable. To prevent misspecification of the model, Jorion (1990) add the return on the market index to control for market movements:

$$R_{i,t} = \beta_{0,i} + \beta_{1,i} \cdot R_{S,t} + \beta_{2,i} \cdot R_{M,t} + \varepsilon_{i,t} \quad (1)$$

where, $R_{i,t}$ is the rate of return on the i^{th} firm's common stock in period t, $R_{S,t}$ is the rate of change in a trade-weighted exchange rate (in dollar per unit of foreign currency) in period t, and $R_{M,t}$ is the rate of return on the CRSP (Centre for Research in Security Prices) value-weighted market index. $\beta_{1,i}$ represents a firm i's exchange rate exposure independent from the effect that these currencies have in the overall market; $\beta_{2,i}$ firm i's return sensitivity to market risk and $\varepsilon_{i,t}$ denotes the white noise error term.

Examining the monthly stock returns of 287 US multinationals in the period from 1971-1987, Jorion (1990) finds that only about 5,5% of the firms are significantly exposed to

[4] We corroborate Bartram's (2005) assertions, when we calculated the standard deviations of the monthly returns of various financial prices risk factors during the period 2006-2008. To represent the exchange risk factor we use a trade-weighted exchange rate index – the Euro effective index (which covers 22 currencies); to represent the interest rate risk factor we make use of the three-month Euribor; and to represent the commodity price risk factor we consider the Euronext Rogers International Commodity Index. The calculated monthly volatilities are 1,35%, 5,82% and 7,3%, respectively.

exchange rate risk. He finds, however, that nine out of 14 foreign firms listed on the NYSE have significant exposures.

As discussed in Bartov and Bodnar (1994) and in several other papers, an appreciation in the domestic currency makes exporting goods more expensive in foreign currency territory, and this may lead to a fall in foreign demand. Consequently, the exporting firm's value would hurt by an appreciation of the domestic currency. On the other hand, importing firms would benefit from the appreciation of the domestic currency because their imports would become cheaper. As a result, the $\beta_{1,i}$ coefficient should be negative for importing and positive for exporting firms.

In line with Jorion (1990), several other studies were carried out. For firms on the stock market in the US, researchers have applied various specifications of the Jorion's framework to investigate the significance of exposure for particular samples of industries or firms, including multinationals firms (e.g., Amihud, 1994; Choi & Prasad, 1995; Jorion, 1991), nonfinancial firms (e.g., Allayannis & Ofek, 2001; Crabb, 2002), firms in the automotive industry (Williamson, 2001) and broader sample of industries (e.g., Bodnar & Gentry, 1993).

Amihud (1994) finds no significant exchange rate exposure for a sample of 32 US exporters from 1982 to 1988. To some extent, Choi and Prasad (1995) provided strong evidence of significant exposure. They examined a sample of 409 multinational firms that have foreign sales, profits and assets of at least 25% of their respective totals. About 15% of the firms are significantly exposed. Furthermore, Bodnar and Gentry (1993) show that roughly 30% of industries in the US, Japan and Canada have significant exposure to exchange rate movements. However, they find that the percentage of industries significantly exposed is smaller for the US than for Canada and Japan, which puts forward that industries in smaller and more open economies are likely to be more exposed to exchange rate risk. In the case of Williamson (2001), that analyses automotive industry in the US, significant exposure occurs only for certain firms.

Whereas most papers focus on US financial markets, several studies have also been surveying other markets, such as Japan (Bodnar & Gentry, 1993; He & Ng, 1998; Williamson, 2001), Canada (Bali *et al.*, 2007; Bodnar & Gentry, 1993), Australia (Khoo, 1994; Nguyen & Faff, 2003), Sweden (Hagelin & Pramborg, 2004; Nydahl, 1999), and broad samples of countries (Bartram, Brown, & Minton, 2010), among others. In general, these studies have had somewhat more success in documenting a significant contemporaneous relation between firm's stock returns and changes in foreign exchange rates. For example, He and Ng (1998), studying exchange rate exposure of Japanese multinational firms over the

period from 1978-1993, find that roughly 25% of the 171 firms in the sample yield significant positive exposure coefficients. Also, Nydahl (1999), analysing the exchange rate exposure of Swedish firms with a foreign sales ratio of at least 10%, finds that approximately 26% of the 47 firms in the sample are significantly exposed to exchange rate changes. On the other hand, Khoo (1994), examining the foreign exchange rate exposure of mining companies in Australia, finds very weak evidence of such exposure. He binds this lack of exposure to the extensive use of hedging by mining firms. Summing up, the empirical evidence on the impact of exchange rates on firm value in non-US markets is not conclusive either.

A controversy point in Jorion's augmented market model concerns the definition of the exchange risk factor. The empirical literature often employs one of the following proxies: a trade weighted exchange rate or a bilateral currency exchange rate, this last under the assumption of a dominant trading currency that affects almost all the firms in the sample. The aforementioned studies typically use a trade-weighted exchange rate index (e.g., Bali *et al*., 2007; Bodnar & Gentry, 1993; He & Ng, 1998; Jorion, 1990, 1991). Despite the view of Williamson (2001), among others, that points out lack of power to the tests using a trade weighted of currencies, when the firm is mostly exposed to only a few currencies, Nydahl (1999), employing alternatively a trade weighted exchange rate index and a bilateral currency exchange rate, concludes that there are not significant differences.

In what respects sampling frequency, the use of monthly data is recurrent (e.g., Allayannis & Ofek, 2001; Bali *et al.*, 2007; Bodnar & Gentry, 1993; Choi & Prasad, 1995; Jorion, 1990). Allayannis and Ofek (2001) justify this option by the fact that daily and weekly exchange rate indices frequently exhibited problems of misalignment between stock return and exchange rate series.

2.2. Interest rate exposure

The majority of interest rate exposure studies are restricted to financial firms, which have mainly financial assets and, thus, are expected to exhibit different sensitivity with regard to changes in interest rates, when compared to nonfinancial firms. At the same time, financial firms have the ability to manage their interest rate risk more accurately because they use sophisticated techniques for the identification and quantification of interest rate exposures. However, changes in interest rates are also important for nonfinancial firms. First, interest rate risk impacts on the value of nonfinancial firms through changes in cash flows generated by operations, which arise due to interest rate direct effect on the cost of capital inherent to investment decisions. In addition, there may be indirect effects of interest rate risk on the

competitive position of firms, impacting also on their expected cash flows. Finally, interest rate risk may influence firms' value due to changes in the value of their financial assets and liabilities.

Within the scope of nonfinancial firms, very little empirical evidence is found concerning interest rate risk impact on firm value. Sweeney and Warga (1986) conducted an extensive study of interest rate sensitivity and pricing in the US stock market. They concluded that changes in the government bonds yields clearly affect to a much larger extent electric utilities industry than the NYSE firms as a whole. Similarly, research on the interest rate sensitivity of nonfinancial firms outside the US is relatively sparse. Prasad and Rajan (1995), using a sample of four industrialized countries in the period from 1981-1989, group individual stock returns data into industry-based portfolios. Their results indicate that interest rate risk varies among countries and that there are industries with significant exposure to interest rate risk, specifically in Japan and Germany. Confirming these results, Bartram (2002) also reports a significant rate exposure in German nonfinancial firms, which is confirmed when several interest risk factors are used.

According to the existing evidence, most of the empirical studies on interest rate risk are based on a two-index model developed by Stone (1974), which includes an interest rate change factor in addition to the traditional market index.

2.3. Commodity price exposure

The economic commodity price exposure describes the effect of unexpected price movements of commodities on firm value. This effect is primarily determined by firms' economic business activity.[5] On the other hand, indirect effects result from the economic interdependence of companies in the economic value chain.[6] In general, a relevance of a commodity as an input (output) factor should lead to a negative (positive) exposure.

Despite the fact that changes of all production factors on the range of products have, potentially, a direct economic effect on the firms' cost and/or revenue, only some inputs and outputs, namely commodities, are traded on the spot/or futures exchanges of international financial markets. Apart from the use of exchange traded derivatives, OTC contracts such as swaps, forwards or more complex financial products can also be used to hedge commodity price risk. As well, the price of various commodities that are not exchange traded can be

[5] For example, energy products are primarily relevant for the power, oil/refining, rubber/plastics, and transportation industries.
[6] For example, impact on competitiveness, pass-through of commodity price changes to costumers.

hedged via cross hedging. This is achievable when their price is highly correlated with some other commodities for which derivatives are available. So, it seems unquestionably the effectiveness of commodity risk management on commodity price exposure reduction; yet, very little attention to this matter has been attracted to date at the empirical literature level.

Exceptions are made to several empirical studies based on American gold mining industry (Petersen & Thiagaranjan, 2000; Tufano, 1998), gas and oil industry (Jin & Jorion, 2006) and airline industry (Carter *et al*., 2006). This is justified by the fact that companies in those industries turn out fairly homogeneous products, which imply relatively simple exposure structures. On the other hand, being industries with strictly disclosing rules brings about the conception of high level databases on risk management practices. These studies make use of the common approach assessed in the literature – a two factor augmented market model, which includes a commodity price change factor.

The few studies that focus on commodity price exposure over a broad sample of nonfinancial firms across multiple industries are the ones by Bartram (2005) and Bali *et al.* (2007). Bartram (2005) makes use of a sample of 490 German nonfinancial firms, but limits his analysis to the sensitivity of firm value toward commodity price risk. Using time series regression, he tests if commodity price risk that has not been hedged may negatively (positively) affect stock prices in industries for which a certain commodity represents an important input (output) factor in the production process. The author reports that the percentage of firms with significant exposure to commodity price risk is in the range of 4,5% - 15,9%. Thus, commodity price risk is not found to be of greater importance than other financial risks. This result is consistent with few corporate cash flows affected by commodity price changes. In the case of the study carried out by Bali *et al.* (2007), the focal point is the interaction between firm's risk exposures, derivatives use and firm's real operations. Their data set includes US and Canadian nonfinancial firms belonging to four-industry SIC code classifications: gold and silver mining, food processing, pharmaceuticals and large biotechnologies, and primary metals processing. Evidence is found that commodity derivatives users have increasingly inherent risk exposure, which may suggest that hedging with derivatives is not always important to a firm's return rate and may be linked to other nonfinancial and economic factors.

2.4. Determinants of financial price exposures

With respect to factors that influence exchange rate exposure, several authors, such as Jorion (1990), Bodnar and Gentry (1993), Amihud (1994), Williamson (2001), Allayannis and Ofek

(2001) and Bali *et al*. (2007) have found in their studies that a higher foreign involvement, proxied by ratio of foreign sales to total sales, implies a stronger correlation between a depreciation (appreciation) of the dollar and an increase (decrease) in stock market values.

When the focus is the interest rate exposure, Bartram (2002) investigates two partial exposure determinants: financial leverage and firm liquidity and finds only a significant relation between interest rate exposure and firm liquidity. Instead, Bali *et al*. (2007) consider only financial leverage as a proxy for firm's real operations.

Williamson (2001), among others, argues that the low significance of empirically exposure coefficients reported may arise from the fact that what is really being measured is the net exposure to exchange rates, or the exposure that remains after the firm has engaged in some hedging activity, whether to the use of derivatives or through its operations. Bartram (2002) emphasized that nonfinancial firms should be able to immunize firm value against changes in interest rates to some extent by matching the interest rate sensitivity of their assets and liabilities through active risk management, but not in the same way as financial intermediaries. Additionally, Bartram (2005) suggested that firms for which commodity price volatility is an important source of risk are likely to efficiently implement their risk management strategies, rendering net commodity price exposure perceived much smaller than gross exposure. It seems likely that, to the extent that hedging activities are efficiently implemented, they have a direct impact on the nature and characteristics of a firm's exposure. In spite of the recognition of the influence of hedging activities on firms' exposures, only a few authors try to incorporate the impact of hedging on exposures analysis.

In the field of commodity price exposure, Tufano (1998) considers the hedging activities to be a potential determinant of exposure. Additionally, he tests several other potential determinants strictly related to gold mining industry: gold production quantity, gold total reserves, average gold price, cost structure, financial leverage, gold return volatility, and percentage of assets in mining. Similarly, Jin and Jorion (2006) investigated the effect of hedging with derivatives and of gas and oil reserves on the commodity price exposure of a sample of US oil and gas firms. Recently, Bali *et al.* (2007) investigated the effect of derivatives use and of real firm's operations, represented by the ratio of total inventory to total sales, on commodity price exposure.

Focusing on internal hedging strategies, Williamson (2001) shows that foreign production decreases exchange rate exposure, which is consistent with the idea that an exporter can counteract the sensitivity of the cash flow to exchange rate movements by having costs denominated in the local currency, that is to say, the success of operational hedging

through production. Corroborating conclusions are drawn by Carter *et al.* (2003). Others authors try to empirically link estimated exposure coefficients with data on foreign hedging activities. Nydahl (1999), Allayannis and Ofek (2001), and also Nguyen and Faff (2003) assess data on foreign exchange derivatives usage; Carter *et al.* (2003), Hagelin and Pramborg (2004) and Bartram *et al.* (2010) consider both, data on internal and external hedging activities. Additionally, Carter *et al.* (2003) account for the fact that the magnitude of a firm's exposure to foreign exchange risk affects its hedging decisions. In other words, they recognize that foreign exchange rate exposure and hedging are endogenously determined.

Another set of studies are based on optimal hedging theories, which postulate that non hedging firms should be more exposed to currency movements than hedging companies (He & Ng, 1998; Nguyen & Faff, 2003). Particularly, He and Ng (1998) use variables that proxy for firm's incentives to hedge to examine the influence of presumed hedging activities.

3. Sample description and methodology

3.1. Sample description

For our estimates, we use a sample restricted to the nonfinancial firms. Nonfinancial firms typically concentrated their efforts on hedging transactions, whereas financial firms include both, hedging and speculative transactions in their risk management activities. Accordingly, the initial sample includes all nonfinancial firms listed on Euronext belonging to the following indexes at December 31, 2007: Brussels all Shares (BAS) Price,[7] CAC all shares,[8] Amsterdam Exchanges (A-DAM) all shares[9] and PSI General.[10] We did not take into account multiple listings by the same firms, selecting the main market where different alternatives arise.

Our final sample is constructed by matching firms with an annual report in English or Portuguese for 2007 published on their web site[11] with firms that have sufficient accounting data, for the same year, and, at least, 15 non-missing monthly share prices reported during the 2006-2008 period on the *Infinancials* database. In addition, we considered only firms that

[7] The BAS price index is a market capitalization weighted index that includes the Belgian stocks that are listed on Euronext Brussels market.
[8] The CAC all shares is a market capitalization weighted price index composed by all stocks listed on Euronext Paris with an annual velocity of more than 5%, irrespective from market capitalization.
[9] The A-DAM all shares index is a market capitalization weighted price index and comprises all shares listed on Euronext Amsterdam market.
[10] The PSI Geral index is a market capitalization weighted index that only includes shares issued by companies that are listed on Euronext Lisbon.
[11] In view of the number of firms that presents annual report in English on the Portuguese sub-sample, we made an exception. We have considered both, firms with annual report presented in Portuguese or in English.

have foreign sales and the necessary hedging data disclosed on annual report. This approach left us with 304 firms in our final sample. Appendix B, Panel A reports how the sample size is reduced by succeeding data requirements.

Infinancials is the source for the accounting and financial information, with the exception of information on foreign firm sales, used in the construction of the variables that proxy for firms' characteristics. Data on inside ownership where obtained from *Bloomberg* database, which provide for each sample firm the proportion of firm's shares owned for each director.

Further, we search annual reports for information's about foreign sales and hedging practices. The availability of consistent data on hedging practices is of major importance in any empirical investigation on this matter. Recent empirical studies have employed qualitative and quantitative proxies of hedging practices based on firms' disclosures on annual reports. However, data collected from this source is often incomplete and differs greatly from firm to firm, even though the quality of disclosure has improved with the adoption of International Accounting Standards (IAS), namely IAS 32 and IAS 39 in January, 2005.[12] Given that many firms in our sample report the use of hedging instruments but do not report their levels, we feel that a qualitative proxy for the non-use/use of hedging instruments is more appropriate than notional amounts. Following Judge (2006), we choose to use a dichotomous variable by category of risk for the use/non-use of hedging instruments.

Following Allayannis and Ofek (2001), the data sets use a firm's monthly returns for the three years surrounding 2007 (2006-2008). We use a trade-weighted exchange risk index – the Euro effective index -[13] to proxy for the foreign exchange risk factor. The proxy used to represent the interest rate risk factor is the three-month Euro Interbank Offered Rate (Euribor). Both the nominal effective exchange rate and the three-month EURIBOR data were obtained from the European Central Bank. To represent the commodity price risk factor we consider the Euronext Rogers International Commodity Index (RICI) provided by Uhlmann Price Securities.[14] The MSCI Euro index provided by Morgan Stanley Capital International

[12] IAS 32, *Financial Instruments: Disclosure and Presentation*, and IAS 39, *Financial Instruments: Recognition and Measurement*, both issued by the International Accounting Standards Board (IASB).

[13] The trade weighted Euro effective exchange rate index (EER) covers 22 currencies. In order of weighting they are Great Britain, USA, Japan, Switzerland, Sweden, China, Hong Kong, Taiwan, Denmark, South Korea, Poland, Singapore, Czech Republic, Russia, Turkey, Hungary, Malaysia, India, Norway, Canada, Thailand and Brazil.

[14] The RICI represents the value of a basket of commodities employed in the global economy, ranging from agricultural and energy products to metals and minerals. The value of this commodity basket is tracked via futures contracts on 35 different exchange-traded physical commodities, quoted in four different currencies, listed on eleven exchanges in five countries.

Barra is used as proxy for equal-weighted returns market index.[15] Finally, we use gross national product per capita to measure country financial market development (Lel, 2009) which originates from the *World Economic Outlook* database *(International Monetary Fund)*.

Firms are classified into industries according to the Industry Classification Benchmark (ICB) classification codes in the *Infinancials* database. This procedure results in firms' distribution by nine industries. Appendix B, Panel B and C show the country and industry composition, respectively. The largest industry (Industrials) represents 27,6% of the sample. Because of our reliance on English language annual reports, the country composition is biased toward Belgium and The Netherlands.

3.2. Methodology

We use a two-step approach procedure to investigate the effect of firm's hedging activities and real operations on its exposure to financial risks. Following Bali *et al.* (2007), this study provides more complete estimates of firms financial risk by extending Jorion (1990) and Allayannis and Ofek (2001) exposure models for currency exchange risk, to also include interest rate and commodity price risk. In the first stage, we estimate the stock exposure of each firm in our 2007 data. In the second stage, we examine the relationship between financial price exposures already estimated, hedging activities and firm's real operations.

A) Time series analysis: Measuring stock price exposure

As mentioned in the previous section, the current approach adopted in literature to estimate a firm's stock exposure to financial price risk is a two factor augmented market model. In line with Bali *et al*. (2007), in the first stage regression we provide estimates of individual firm's exposure by category of risk using a four-factor augmented market model:

$$R_{i,t} = \beta_{0,i} + \beta_{1,i} \cdot FX_t + \beta_{2,i} \cdot \Delta IR_t + \beta_{3,i} \cdot CP_t + \beta_{4,i} \cdot MSCI_t + \varepsilon_{i,t} \qquad (2)$$

where

$R_{i,t}$ = the stock rate of return for firm *i* in month *t* is computing using the following expression:

$$R_{i,t} = \frac{P_{i,t} - P_{i,t-1}}{P_{i,t-1}} \qquad (3)$$

where, *P* refers to the closing price for the time series January 31, 2006

[15] The MSCI Euro index is a subset of the MSCI Pan-Euro index and includes the largest and most liquid stocks from the ten European Union countries. The countries included in the index are: Austria, Belgium, Finland, France, Germany, Ireland, Italy, The Netherlands, Portugal and Spain.

until December 31, 2008. The returns are adjusted for the payment of dividends and stock splits;

FX_t = the rate of return on a moving trade-weighted average exchange rate index in period *t*;

ΔIR_t = the monthly rate of change in the short-term interest rate factor in period *t*;

CP_t = the monthly rate of return on a commodity index in period *t*;

$MSCI_t$ = the monthly rate of return on the MSCI Euro index in period *t*,

$\varepsilon_{i,t}$ = noise error term.

In equation (2) each non-intercept term β represents a firm's exposure by category of risk. The coefficient $\beta_{1,i}$ represents the exchange rate exposure, $\beta_{2,i}$ represents the interest rate exposure, $\beta_{3,i}$ represents the commodity price exposure and $\beta_{4,i}$ firm *i*'s return sensitivity to market risk.

B) Cross sectional analysis: Determinants of financial price exposure

Previous studies (e.g., Allayannis & Ofek, 2001; Carter *et al.*, 2003; Hagelin & Pramborg, 2004; He & Ng, 1998; Nydahl, 1999) analyzed the efficiency of hedging activities by examining the determinants of the financial price exposure in a cross sectional regression with the exposure coefficients estimated for each category of risk as the dependent variable.

Carter *et al.* (2003) suggest that financial risk management and the level of exposure are possibly endogenous. Several other authors argue that firms with more exposure have higher probabilities of becoming hedgers (e.g., Bartram *et al.*, 2009; Lel, 2009). In that sense, if financial exposures and hedging activities are interrelated, then financial exposures should be a function of hedging activities and of firm's real operations (Bali *et al.*, 2007; Bartram, 2002). Similarly, hedging instruments usage should be a function of the financial price exposures magnitude and of other factors also related with firms hedging decisions. In order to determine whether this is the case, the following system of simultaneous equations for each category of risk is formulated:

(i) For exchange rate exposure:

$$|\beta_{1,i}| = \alpha_0 + \alpha_1 \cdot DUM\_FX_i + \alpha_2 \cdot FS/TS_i + \eta_i \quad (4)$$

$$DUM\_FX_i = \delta_0 + \delta_1 \cdot |\beta_{1,i}| + \delta_2 \cdot TAX_i + \delta_3 \cdot LEV_i + \delta_4 \cdot CAPEX_i + \delta_5 \cdot PE_i + \delta_6 \cdot INS_i + \delta_7 \cdot ASSET_i + \delta_8 \cdot DIV_i + \delta_9 \cdot GDP_i + \xi_i \quad (5)$$

(ii) For interest rate exposure:

$$|\beta_{2,i}| = \alpha_0 + \alpha_1 \cdot DUM\_IR_i + \alpha_2 \cdot LIQ_i + \eta_i \quad (6)$$

$$DUM\_IR_i = \delta_0 + \delta_1 \cdot |\beta_{2,i}| + \delta_2 \cdot TAX_i + \delta_3 \cdot LEV_i + \delta_4 \cdot CAPEX_i + \delta_5 \cdot PE_i + \delta_6 \cdot INS_i + \delta_7 \cdot ASSET_i + \delta_8 \cdot DIV_i + \delta_9 \cdot GDP_i + \xi_i \quad (7)$$

(iii) For commodity price exposure:

$$|\beta_{3,i}| = \alpha_0 + \alpha_1 \cdot DUM\_CP_i + \alpha_2 \cdot TI/TS_i + \eta_i \quad (8)$$

$$DUM\_CP_i = \delta_0 + \delta_1 \cdot |\beta_{3,i}| + \delta_2 \cdot TAX_i + \delta_3 \cdot LEV_i + \delta_4 \cdot CAPEX_i + \delta_5 \cdot PE_i + \delta_6 \cdot INS_i + \delta_7 \cdot ASSET_i + \delta_8 \cdot DIV_i + \delta_9 \cdot GDP_i + \xi_i \quad (9)$$

where:

$\|\beta_1\|$	=	magnitude of the exchange rate exposure;
$\|\beta_2\|$	=	magnitude of the interest rate exposure;
$\|\beta_3\|$	=	magnitude of the commodity price exposure;
ASSET	=	natural logarithm of total assets;
CAPEX	=	ratio of capital expenditures to total assets;
DIV	=	dividend yield, measured by gross dividend per share divided by closing stock price;
DUM_FX	=	dummy which is assigned a value of 1 if a firm uses external and/or internal foreign exchange hedging instruments; 0 = otherwise;
DUM_IR	=	dummy which is assigned a value of 1 if a firm uses external and/or internal interest rate hedging instruments; 0 = otherwise;
DUM_CP	=	dummy which is assigned a value of 1 if a firm uses external and/or internal commodity hedging instruments; 0 = otherwise;.
FS/TS	=	ratio of foreign sales to total sales as a proxy for firm's real foreign operations;
GDP	=	natural logarithm of gross national product per capita;
INS	=	percentage of ordinary shares held by insiders;
LEV	=	financial leverage, measured by ratio of total debt to total assets;
LIQ	=	ratio of cash-flow to total assets as a proxy for the expected costs of financial distress;
PE	=	price earnings ratio;
TAX	=	net operating losses to total assets;
TI/TS	=	revenues from commodity operations, measured by ratio of total inventory to total sales;

In our estimation of equations (4), (6) and (8) we test if a firms' use of hedging instruments affects its exposure to the underlying risk factor. If firms use risk management instruments' as a hedge against financial risk exposures, the absolute value of exposure should be negatively related to risk management instruments use.[16] If, on the other hand, firms use risk management instruments, namely derivatives, to speculate, we should expect a positive relation between risk management instruments' use and the absolute value of inherent financial price risks. Additionally, in equations (4), (6) and (8) we test if a firm's real operations are important determinants of specific risk exposure. With respect to exchange rate exposure, is expected that net exporter firms exhibit a positive exchange rate exposure when euro appreciates. In contrast, if a firm is a net importer the appreciation of the euro should produce a negative exposure. On the other hand, for a given exposure, an increase in revenues from foreign operations should always increase exposure. However, when we take the absolute value of exchange rate exposure, we cannot hypothesize any relation between the absolute value of exposure and the ratio of foreign sales to sales (e.g., Allayannis & Ofek, 2001). Similarly, we take the same approach for commodity price exposure, supported on the fact that commodities can be identified empirically in a particular industry either as an input factor or as an output factor in the production process (Bartram, 2005). In what concerns interest rate exposure, we hypothesize, similarly to Bartram (2002), that firms with high level of liquidity have less significant expected costs of financial distress. As a result, one can expect the interest rate exposure to be negatively related with firms' liquidity.

In line with the optimal hedging theory, the ratio of net operating losses to total assets (*TAX*) proxy's for the convexity of firm's tax schedules. The great majority of the variables that are used to test the relation between taxes and derivatives usage are based on the existence of net operating losses (e.g., Géczy, Minton, & Schrand, 1997; Howton & Perfect, 1998; Marsden & Prevost, 2005; Nance, Smith, & Smithson, 1993; Tufano, 1996). Usually, the hypothesis tested is as follows: the greater the firm's probability of incurrence in tax loss which will be carried forwards, the greater the probability of the firm's engagement in hedging should be. Therefore, we expect a positive coefficient for the tax variable.

The second control variable is leverage (*LEV*), which is a proxy for the probability of financial distress (Lel, 2009; among others). We expect firms with greater degree of financial distress to engage more often in hedging activities. Measuring financial distress costs by

[16] In what respects exchange rate exposure, the use of risk management instruments should decrease exchange rate exposure for firms with positive exposures and increase (decrease in absolute value) exchange rate exposure for firms with negative exposures.

leverage levels relies on the implicit assumption that firms with important gearing in their capital structure have greater probability of facing financial distress. Leverage is measured by debt ratio (e.g., Berkman & Bradbury, 1996; Gay & Nam, 1998; Graham & Rogers, 2002).

The theory predicts that hedging can enhance firms' value if it can decrease the agency costs of debt. It was suggested that these agency costs of debt are more evident in firms with more growth options, as these firms could have a high probability of underinvestment or asset substitution. In general, to control for this last argument, studies include variables representing firms' available growth opportunities. In line with Lin and Smith (2008), we use, to proxy for investment, the ratio of capital expenditures to total assets (*CAPEX*), and we use, to proxy for growth opportunities, the price to earnings ratio (*PE*). Hence, if risk management is used to protect the continued funding of futures investment programs, we expect a positive relationship between hedging activities and both variables.

In testing managerial risk aversion prediction, we use percentage of ordinary shares held by insiders (*INS*) (e.g., Bartram *et al*., 2009; Berkman & Bradbury, 1996; Fok, Carroll, & Chiou, 1997; Mardsen & Prevost, 2005). Risk adverse managers tend to use hedging if they have relatively undiversified financial and human capital and if it is costly to hedge it on their own account. Stulz (1984) and Smith and Stulz (1985) argue that managers have greater incentives to hedge when their wealth is more closely tied to their firms' well-being.

To control for firm size we use as a proxy the natural logarithm of the total assets (*ASSET*). We need to control for firm size because the establishment and implementation of a hedging programme involve some fixed costs (Nance *et al*., 1993). Larger firms that have access to risk management expertise, or that have economies of scale in hedging costs, are more likely to hedge than smaller firms. However, there are circumstances where smaller firms have more incentive to hedge than larger firms; for instance, smaller firms will hedge more, because they face greater bankruptcy costs. Thus, the effect of firm size on hedging activities is ambiguous and shall be empirically determined. Similarly, because larger economies are likely to have larger and more liquid financial markets, we include gross national product per capita (*GDP*) to control for the availability of derivatives and their costs (Lel, 2009).

The presence of liquid assets could also reduce the need for hedging with derivatives (e.g., Davies, Eckberg, & Marshall, 2006; Géczy *et al*., 1997; Marsden & Prevost, 2005; Nance *et al*., 1993; Tufano, 1996). The common approach consists on using measures of liquidity or the dividend yield. In fact, holding cash or other liquid assets allows firms to cover temporary shortfalls in revenues and to fulfil short term liabilities. As a result, the

probability of encountering financial distress is reduced. In addition, higher dividend payouts could indicate more liquidity. We control for liquidity through dividend yield (*DIV*) and expect that firms with higher dividend payouts are less likely to hedge.

So, consistent with previous studies on optimal hedging theories δ_1, δ_2, δ_3, δ_4, δ_5, δ_6 and δ_9 in equations (5), (7) and (9) are expected to be positive. In contrast, δ_8 is expected to be negative and δ_7 could be either positive or negative.

In a subsequent step, we investigate if an increase in hedging in one category of risk may reduce the exposure to risk in another category. For this test we substitute *DUM_FX*, *DUM_IR* and *DUM_CP* with *DUM_ALL*. *DUM_ALL* is assigned a value of 1 if a firm uses external and/or internal hedging instruments; 0 in the otherwise situation.

Our system of equations includes nine exogenous and two endogenous variables. The order condition for identification states that if an equation is to be identified, the number of predetermined variables excluded from the equation must be greater than, or equal to, the number of the included endogenous variables minus one. Therefore, at least one of the exogenous variables must be excluded from any single equation to identify the system. However, our development of the system of equations is motivated independently from the requirement for these identification restrictions to be met. As a result, regarding the order condition for identification, the first equation of our system is over-identified and the second equation is exactly-identified.

As can be observed, our model includes two equations: one with an observed continuous endogenous variable that have to be estimated using OLS, and the other with an unobserved endogenous variable which requires Probit estimation. In this case, the standard approach to simultaneous equations – 2SLS or 3SLS – will lead to biased and inconsistent estimates of the coefficients. Yet, such models can be combined into multi-equation systems in which the errors share a multivariate normal distribution. The literature has historically focused on multi-stage procedures for estimating mixed models, which are more efficient computationally, if less so statistically (e.g., Maddala, 1983, chapters 7 and 8), than maximum likelihood (ML). But in the meantime direct ML fitting become more practical. Therefore, we test the interaction between financial price exposures and hedging activities by using the iterated Seemingly Unrelated Regression (SUR) framework, in Gretl (version 1.9.1). Really, iterated SUR is not a true ML estimator, but it converges to the same solution as ML-based SUR.

4. Results and discussion

In Table 1 we report the percentage of hedgers and non hedgers by category of risk instrument. As may be observed the percentage of hedgers is generally high, 78,6% for exchange rate hedgers and 61,2% for interest rate hedgers. Exception is made to commodity hedging instruments usage. Only 17,8% of the firms on the sample use commodity hedging instruments, which may be consistent with Bartram's (2005) view that only few corporate cash flows are affected by commodity price changes.

(Insert Table 1 about here)

Table 2 shows some descriptive statistics of the above listed variables. In average, about 24% of firms' total assets are financed by debt. The average value of the size variable is 16,165. This converts in about € 10.480 millions. The average percentage of foreign sales is 29,7%, firms' inventory represents, on average, 18,3% of total sales and the average liquidity ratio is 6,9%.

(Insert Table 2 about here)

A) Time series analysis: Measuring stock price exposure

Before we investigate the firms' financial price exposure, we investigate the series stationarity properties. The augmented Dickey-Fuller (ADF) test is applied to each time series for return on individual securities, return on Euro Effective Index, the rate of change in the three-month EURIBOR interest rate, return on the Euronext Rogers International Commodity Index, and return on MSCI Euro Index to discard the existence of the unit root in the series analysed. To carry out ADF regressions we have to set the number of lagged terms to include in the test.[17] We performed ADF test based on a regression with a constant and a trend, a regression with a constant, and a regression without constant. We considered a maximum nine lagged terms.

The vast majority of our time series for returns on individual securities is integrated of order zero; 16,1% of our time series are integrated of order one and 1,6% are integrated of

[17] When we deal with monthly data, Schwert (1989) suggested the following expression to determine the number of lagged terms:

$$\text{Max Lags} = \text{Int}\left[12 \times \left(1/100\right)^{1/4}\right]$$

superior order. In what concerns the financial price exposure factors and the market index, they are all stationary on the levels. We also investigated the serial autocorrelation and, in line with Fama (1990), we have applied ARMA specification only to the time series on the return of the Euronext Rogers International Commodity Index, in order to achieve a specification of the variable with white noise residuals (the so-called innovations).[18]

The relation between changes in stock prices and changes in financial price exposure factors is analysed by estimating equation (2). Standard errors of the coefficients are estimated by using the Newey-West method to correct for autocorrelation and heteroscedasticity. For all the categories of risk, the regression yields a percentage of firms with significant exposure below the 10% significance level (Table 3).

(Insert Table 3 about here)

The interest rate exposure factor shows the highest significance, with a percentage of 34,9%. Additionally, with regard to the other exposure factors, firms exhibit higher percentages of significant cases when compared with previous empirical studies presented in Appendix A. For instance, for the US market, Jorion (1990) shows that only 5% of his sample exhibits significant exchange rate exposure, while Choi and Prasad (1995) document that 15% of their sample experiences significant exchange risk sensitivity. Focusing on the Japanese market, He and Ng (1998) report that about 25% of their sample has significant exchange rate exposure, and for Swedish firms, Nydahl (1999) finds 26% of the firms to be significantly exposed. In fact, our results corroborate Bodnar and Gentry's (1993) assertion that firms in smaller and more open economies are likely to be more exposed to exchange rate risk.[19]

Similarly, in the scope of interest rate exposure and of commodity price exposure, our study documents higher levels of exposure when compared with the findings of earlier studies. For German firms, Bartram (2002) finds a linear interest rate exposure in the range of 6,4% to 18,8%, and Bartram (2005) finds that the fraction of sample firms with statistically significant commodity price exposure is roughly 4,5% to 15,9%.

[18] Time series stationarity analysis is available upon request.

[19] On the year 2007, Belgian exports and imports were 70,5% and 70% of GDP, respectively; French exports and imports were 21% and 23,2% of GDP, respectively; Dutch exports and imports were 59,4% and 52,3% of GDP, respectively; and Portuguese exports and imports were 23,3% and 34,1% of GDP, respectively. In comparison, in the US exports and imports were only 8,3% and 14,3% of GDP, respectively (CIA, 2007).

B) Cross sectional analysis: Determinants of financial price exposure

In a first stage, we estimate the model with the continuous variable (financial price exposure) as a dependent variable in the usual fashion, using OLS, while the model for the binary choice variable (hedging activities) is estimated via Probit. However, *DUM_CP* Probit model does not achieve ML convergence, that's why, specifically for this case, we use OLS estimation. Besides, when we perform the normality tests the results highlights that the model disturbance are not jointly normally distributed and this is probably the reason why the ML estimator process do not converge.

Similar OLS and Probit regressions have been standard in the literature, but they ignore the possible interrelation between financial price exposures and hedging activities. So, in a second stage, this interrelationship is tested with a system of simultaneous equations, by applying the SUR procedure on the equations (4) – (9) described above. This procedure treats financial price exposures and hedging as endogenous variables. The main reason for using OLS and Probit analysis in the first stage is that the results that are obtained by it are useful for assessing the extent to which the results obtained by using SUR are influenced by the use of the technique. We present the summary of the OLS/Probit and SUR results in Table 4 and Table 5.

(Insert Table 4 and 5 about here)

First stage: Unlike prior studies, the results of the OLS regression indicate that currency hedging activities and the degree of firms operations do not have a statistically significant influence on the magnitude of exchange rate exposure. Moreover, we investigate the fact that an increase in hedging in one category of risk may reduce the exposure to risk in another category; specifically, we substitute the variable that represents currency hedging by the variable that proxy for the hedging instruments inherent to all categories of risk (*DUM_ALL*). This new specification exhibits, as expected, a significant negative effect of hedging on exchange risk exposure. In addition, Probit analysis put forward that the magnitude of the exposure does not have a significant influence on the variable that proxy's for currency hedging activities. This result is achieved also at the level of *DUM_ALL* specification.

Within the scope of interest rate exposure the OLS and Probit analysis do not establish any significant link between exposure and hedging. Lastly, in what concerns the commodity price exposure, OLS results indicates that commodity hedging activities significantly impact absolute exposure, but in sign opposite from what is expected. This result indicates that firms'

commodity hedging activities could be driven by reasons others than the management of existing exposures; eventually commodity derivatives are used for speculative purposes. In what concerns Probit analysis, the magnitude of commodity price exposure, as expected, is positively associated with commodity hedging activities. However, when we consider the use of the *DUM_ALL* specification, we do not find any significant influence, neither in the scope of interest rate exposure, nor in the commodity price exposure. As for the question of whether the revenues from commodity operations impact absolute value of commodity exposure, all results converge to an insignificant impact.

In examining the control variables on the equations (5), (7) and (9), we verify that there exists variation for the determinants of each type of hedging instruments. The Probit results indicate that size (*ASSET*) and gross national product per capita (*GDP*) have a positive and dividend yield (*DIV*) a negative influence on currency hedging instruments usage. These results are largely consistent with expectations: larger firms that have access to risk management expertise, or that have economies of scale in hedging costs, are more likely to hedge; firms established in countries with more liquid financial markets are more likely to hedge; and, firms with higher dividend yield are less likely to be financially constrained, so hedge less. Also, as expected, the Probit results indicate that size (*ASSET*), gross national product per capita (*GDP*) and financial leverage (*LEV*) have a significant positive effect on interest rate hedging activities. Leverage variable results suggest that firms with greater degree of financial distress engage more often in hedging activities.

Contrary to expectations, the percentage of ordinary shares held by insiders (*INS*) impacts negatively on the use of currency and interest rate hedging instruments. These results are consistent with the management entrenchment hypothesis and/or the signalling hypothesis (Fok *et al.*, 1997). Indeed, when managers accumulate stock, the capability of outside investors to monitor managerial non-value activities decreases; so, they are in better position to become entrenched. On this matter, Morck, Shleifer and Vishny (1988) documented a negative ownership-performance relationship when managerial ownership is in the range of 5% to 25%. In our sample the average insider ownership is around 5,0%. Thus, our results could be driven by the management entrenchment hypothesis. In what respects the signalling hypothesis, it is suggested that higher managerial ownership signals a high firm value due to the fact that managers' interests are more aligned with outside shareholders' interests. In the same way, hedging may signal higher expected future cash flows. So, our negative relation between managerial ownership and hedging can be attributed to the substitutability between hedging and insider ownership as a signal to investors. Finally, and also contrary to

expectations, net operating losses (*TAX*) has a negative effect in the use of interest rate hedging instruments. This is in line with Graham and Smith (1999) that documented a tax disincentive to hedge when net operating losses exist, but limited to companies with expected losses. They documented that existing net operating losses provide a tax disincentive to hedge for companies with expected losses but provide an incentive to hedge for companies that are expected to be profitable. In fact, variables based on existing net operating losses can work backwards for expected loss firms. Graham and Smith (1999) also show that the firms that are most likely to have convex tax functions are small, have expected income near zero and alternate between profits and losses. In our sample, firms that recently accumulate losses tend to be small, which suggest that these firms might find the fixed costs associated with hedging programs implementation unaffordable, and as a result, not hedge at all.

When we test if the increase in hedging in one category of risk reduce the exposure to risk in another category (*DUM_ALL* specification), we achieve more consistent results for all the categories of financial risk exposures. Once again, we verify that larger firms, higher levered firms and firms that operate in more liquid financial markets are more prone to hedge. Although insider ownership influences the probability of hedging, this influence is not as expected. As a justification, we suggest that entrenched management may not consider it important to increase shareholder value through hedging.

Second stage: Finally, taking into account a possible interrelation among financial risk exposures and hedging, we estimate the equations (4), (6) and (8) along with equations (5), (7) and (9) respectively, corresponding each pair of equations to an identified category of risk, by applying a simultaneous equations system using SUR procedure.

The results of the SUR regression indicate, as expected, that currency hedging instruments' usage have a negative influence in inherent exposure (e.g., Allayannis & Ofek, 2001). Contrasting with Jorion (1990) conclusions, our results do not corroborate the predicted influence of foreign firms operations on the magnitude of exchange rate exposure. Surprising is the statistically evidence that the magnitude of exchange rate exposure negatively influences hedging with currency hedging instruments. This result indicates that firms' risk management activities could be driven by reasons others than the management of existing exposures; it is possible that derivatives are used for speculative purposes. As for the *DUM_ALL* specification, the results of SUR regression are equivalent. Summing up, our results corroborate the existence of a significant interaction between the magnitude of the exposure and hedging activities in the extent of exchange rate risk.

Within the scope of the interest rate exposure, the SUR results indicate that an interrelation between the magnitude of interest rate exposure and hedging activities does not exist. In addition, there is no significant effect of liquidity on interest rate exposure.

Again, our SUR results show that commodity hedging activities has, contrary to the expectations, a statistically positive effect on commodity price exposure. Also, we find evidence that the magnitude of commodity exposure positively impact on the inherent hedging activities, which suggests that commodity hedging activities is endogenously related to its commodity price exposure. When *DUM_ALL* specification is taken into account, we find, in line with Tufano (1996) and Petersen and Thiagarajan (2000), that hedging activities have a significant negative effect on commodity price exposure. However, the positive effect of exposure on hedging activities disappears.

Overall, we verify that the main SUR results related to the hedging determinants by category of risk are similar to those reported on our "first stage" analysis. Once more, when we consider *DUM_ALL* specification, we verify that size (*ASSET*), gross national product per capita (*GDP*) and financial leverage (*LEV*) have, as expected, a positive influence on hedging activities and that insider ownership (*INS*) have, consistent with the management entrenchment hypothesis and/or the signalling hypothesis, a negative influence on hedging.

5. Conclusions and further directions

This paper presents a comprehensive investigation of the financial risk exposures of European nonfinancial firms, based on the analysis of 304 firms during the period from 2006-2008. We built on previous studies that have been used multifactor market models to access the level of financial risk exposures (exchange rate exposure, interest rate exposure and commodity price exposure), all together. In addition, taking into consideration the influence of both internal and external hedging instruments, we extend the recent investigation on the determinants of such exposures, recognizing that financial risk exposure and hedging are endogenous.

We document that our sample firms exhibit higher percentages of exposure to the three categories of risk when compared with previous empirical studies. In addition, we find evidence that hedging activities are an important determinant of firm's exchange rate and commodity price exposures, explicitly when we consider the interdependence between the three categories of risk and the hypothesis of simultaneous determination of exposure and hedging activities. In fact, we find several reliable results when we consider that the increase in hedging in one category of risk reduces the exposure to risk in another category. As for the association between firm's real operations and inherent exposures, we do not find any

empirical evidence on the matter. Our results are also consistent with the assertion that exposure and hedging activities are simultaneously determined, but restricted to exchange rate exposure and commodity exposure analysis.

At last, in what respects the remaining determinants of hedging activities, there is some evidence that firms with higher dividend yield are less likely to be financially constrained, which means that they hedge less with exchange rate instruments. In addition, we find contradictory results for the tax hypothesis, namely, we report that our sample firms' that recently accumulate losses are small and hedge less with interest rate instruments. This result runs in favour of the economies-of-scale-in-hedging argument. On the whole, we consistently verify that (i) larger firms have a stronger tendency to hedge, which supports the economies-of-scale-in-hedging argument; (ii) higher levered firms are more likely to hedge, which indicates that firm's hedge to reduce the probability of financial distress; (iii) firms acting in more liquid financial markets are more likely to hedge; and, (iv) firms with high insider ownership are less likely to hedge, which is consistent with the management entrenchment hypothesis and/or the signalling hypothesis.

A possible limitation appointed to this kind of study is the fact that the measure of exposure used seeks to represent already a net exposure, that is to say, the exposure that remains after the firm has engaged in some hedging activity. We suggest, for further research, the search for better measures of financial risk exposures.

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Table 1:

Summary Statistics of Hedging by Category of Risk Instrument

	All Categories		Exchange rate		Interest rate		Commodity	
	Obs.	% of sample	Obs.	% of sample	Obs.	% of sample	Obs.	% of sample
Hedgers	263	86,5%	239	78,6%	186	61,2%	54	17,8%
Non hedgers	41	13,5%	65	21,4%	118	38,8%	250	82,2%

Note. This table reports the use of risk management instruments for the sample of 304 firms. The second column provides data on the number of hedging and non hedging firms; the fourth, sixth and eighth columns report the number of hedgers and non hedgers by category of risk instrument.

Table 2:

Sample Summary Statistics

Variables	Mean	Std. dev.	Minimum	Maximum
ASSET	16,165	4,135	8,790	25,950
CAPEX	0,052	0,048	-0,063	0,318
DIV	0,021	0,020	0	0,117
FS/TS	0,297	0,264	0	0,985
GDP	10,276	0,244	9,641	10,438
INS	0,050	0,124	0	0,812
LEV	0,238	0,172	0	1,000
LIQ	0,069	0,106	-1,000	0,479
PE	17,422	21,186	0	217,890
TAX	0,015	0,062	0	0,469
TI/TS	0,183	0,994	0	16,986

Note. The statistics reported are obtained through Gretl (version 1.9.1). ASSET = proxy for firm size, measured by the natural logarithm of total assets; CAPEX = proxy for firm investment, measured by the ratio of capital expenditures to total assets; DIV = dividend yield proxy for firm liquidity, measured by the gross dividend per share divided by the closing stock price; FS/TS = proxy for firms' foreign real operations, measured by the ratio of foreign sales to total sales; GDP = proxy for the availability of derivatives in capital markets, measured by the natural logarithm of gross national product per capita; INS = proxy for the managerial risk aversion, measured by the percentage of ordinary shares held by insiders; LEV = financial leverage proxy for the probability of financial distress, measured by the ratio of total debt to total assets; LIQ = proxy for the expected costs of financial distress, measured by the ratio of cash-flow to total assets; PE = proxy for growth opportunities, measured by the price earnings ratio; TAX = proxy for the convexity of firm tax schedule, measured by net operating losses to total assets; TI/TS = proxy for the need to hedge commodity price, measured by the ratio of total inventory to total sales. All the accounting variables, with the exception of foreign firms' sales, insider ownership and GDP, originate from the *Infinancials* database. Data on firms' foreign sales was manually collected from firms' annual reports. Data on insider ownership originates from *Bloomberg* database and data on GDP originates from *World Economic Outlook* database *(International Monetary Fund)*.

Table 3:
Summary Statistics on Financial Price Exposures

Panel A. Descriptive statistics of exchange rate exposure coefficients					
	All Cases	Belgium	France	The Netherlands	Portugal
Mean	-0,545	-0,512	-0,600	-0,079	-1,411
Minimum	-42,386	-7,149	-4,359	-7,340	-42,386
Maximum	8,413	6,012	4,351	6,258	8,413
Std. Dev.	3,204	2,315	1,727	2,232	7,272
Nº positive/negative cases	112/192	28/43	37/79	35/44	12/26
% significant cases	28,3%	26,8%	33,6%	26,6%	18,4%
Panel B. Descriptive statistics of interest rate exposure coefficients					
	All Cases	Belgium	France	The Netherlands	Portugal
Mean	-0,186	-0,243	-0,183	-0,035	-0,401
Minimum	-5,467	-1,704	-2,411	-0,506	-5,467
Maximum	1,066	1,025	1,066	1,042	0,560
Std. Dev.	0,546	0,559	0,503	0,185	0,943
Nº positive/negative cases	108/196	25/46	43/73	33/46	7/31
% significant cases	34,9%	31,0%	35,3%	41,8%	26,3%
Panel C. Descriptive statistics of commodity price exposure coefficients					
	All Cases	Belgium	France	The Netherlands	Portugal
Mean	-0,044	0,040	0,092	0,100	-0,208
Minimum	-1,860	-0,677	-0,745	-0,990	-1,860
Maximum	1,395	1,395	1,335	0,968	0,793
Std. Dev.	0,385	0,333	0,331	0,362	0,554
Nº positive/negative cases	164/140	38/33	67/49	47/32	12/26
% significant cases	22,4%	21,1%	22,4%	25,3%	18,4%

Note. This table reports descriptive statistics of β_{ix} - the exchange rate exposure (Panel A), the interest rate exposure (Panel B) and the commodity price exposure (Panel C) – estimated from the following equation for the period January 31, 2006 until December 31, 2008:

$$R_{i,t} = \beta_{0,i} + \beta_{1,i} \cdot FX_t + \beta_{2,i} \cdot \Delta IR_t + \beta_{3,i} \cdot CP_t + \beta_{4,i} \cdot MSCI_t + \varepsilon_{i,t} \quad ,$$

where $R_{i,t}$ is the rate of return on the i^{th} firm's common stock in period *t*, FX_t is the rate of return on the Euro Effective Index in period *t*, ΔIR_t is the rate of change in the three-month EURIBOR in period *t*, CP_t is the rate of return on the Euronext Rogers International Commodity Index in period *t*, and $MSCI_t$ is the rate of return on the MSCI Euro Index in period *t*. The percentage of significant cases is achieved at 10% or lower levels of significance.

Table 4:

SUR and OLS/Probit Regression Results when Hedging Variable is assigned by Category of Risk

Independent variables	Dependent variables in the OLS/Probit regression						Dependent variables in the SUR regression						Predicted Influence
	$\|\beta_1\|$[a]	DUM_FX[b]	$\|\beta_2\|$[a]	DUM_IR[b]	$\|\beta_3\|$[a]	DUM_CP[a]	$\|\beta_1\|$	DUM_FX	$\|\beta_2\|$	DUM_IR	$\|\beta_3\|$	DUM_CP	
Const	2,272	-13,777					2,707	-3,941					
	(6,64)*	(-3,61)*					(7,97)*	(-3,73)*					
$\|\beta_1\|$		-0,014						-0,018					+
		(-0,43)*						(-2,19)*					
FS/TS	-0,083						0,036						na
	(-0,12)						(0,06)						
DUM_FX	-0,634						-1,208						-
	(-1,49)						(-2,85)*						
Const			0,343	-17,636					0,350	-3,750			
			(7,50)*	(-4,20)*					(7,67)*	(-3,37)*			
$\|\beta_2\|$				0,073						0,011			+
				(0,38)						(0,23)			
LIQ			-0,081						-0,076				-
			(-0,31)						(-0,29)				
DUM_IR			-0,016						-0,027				-
			(-0,29)						(-0,48)				
Const					0,267	-0,789					0,260	-0,816	
					(15,81)*	(0,75)					(15,13)*	(-0,79)	
$\|\beta_3\|$						0,192						0,341	+
						(2,27)*						(4,13)*	
TI/TS					-0,010						-0,010		na
					(-0,68)						(-0,63)		
DUM_CP					0,078						0,151		-
					(1,95)*						(3,82)*		

(*continued*)

Table 4 *(continued)*:

SUR and OLS/Probit Regression Results when Hedging Variable is assigned by Category of Risk

Independent variables	Dependent variables in the OLS/Probit regression						Dependent variables in the SUR regression						Predicted Influence
	$\|\beta_1\|$[a]	DUM_FX[b]	$\|\beta_2\|$[a]	DUM_IR[b]	$\|\beta_3\|$[a]	DUM_CP[a]	$\|\beta_1\|$	DUM_FX	$\|\beta_2\|$	DUM_IR	$\|\beta_3\|$	DUM_CP	
Control variables:													
ASSET		0,062		0,154		0,008		0,015		0,038		0,008	na
		(2,61)*		(6,06)*		(1,44)		(2,67)*		(6,70)*		(1,43)	
CAPEX		0,919		2,481		-0,424		0,290		0,623		-0,416	+
		(0,52)		(1,31)		(-0,92)		(0,63)		(1,30)		(-0,92)	
DIV		-10,229		4,006		1,315		-2,805		1,187		1,283	-
		(-2,34)*		(0,95)		(1,14)		(-2,46)*		(0,99)		(1,14)	
GDP		1,364		1,405		0,077		0,449		0,337		0,075	+
		(3,67)*		(3,52)*		(0,75)		(4,39)*		(3,13)*		(0,75)	
INS		-1,455		-2,964		-0,017		-0,389		-0,736		-0,016	+
		(-2,31)*		(-3,71)*		(-0,09)		(-2,21)*		(-3,97)*		(-0,09)	
LEV		0,100		4,446		0,071		0,024		1,101		0,071	+
		(0,19)		(6,87)*		(0,50)		(0,17)		(7,43)*		(0,51)	
PE		-0,006		0,001		$-9{,}3e^{-03}$		-0,002		$-1{,}6e^{-03}$		$-9{,}1e^{-03}$	+
		(-1,43)		(0,30)		(-0,87)		(-1,61)		(-0,14)		(-0,87)	
TAX		-0,742		-4,591		-0,620		-0,208		-0,886		-0,600	+
		(-0,51)		(-1,70)*		(-1,58)		(-0,54)		(-2,17)*		(-1,57)	
R^2	0,010	0,134	0,001	0,325	0,014	0,048	---		---		---		

Note. The statistics reported are obtained through Gretl (version 1.9.1). In the predicted influence column – na – means that there is no prediction. *t*-values are in parentheses. $|\beta_1|$, $|\beta_2|$ and $|\beta_3|$ represent the magnitude of exchange rate exposure, the magnitude of interest rate exposure and the magnitude of commodity price exposure, respectively; ASSET = proxy for firm size, measured by the natural logarithm of total assets; CAPEX = proxy for firm investment, measured by the ratio of capital expenditures to total assets; DIV = dividend yield proxy for firm liquidity, measured by the gross dividend per share divided by the closing stock price; *DUM_FX, DUM_IR* and *DUM_CP* are dummies which are assigned a value of 1 if a firm uses either external or internal foreign exchange hedging instruments, interest rate hedging instruments and commodity hedging instruments, respectively; FS/TS = proxy for firm foreign real operations, measured by the ratio of foreign sales to total sales; GDP = proxy for the availability of derivatives in capital markets, measured by the natural logarithm of gross national product per capita; INS = proxy for the managerial risk aversion, measured by the percentage of ordinary shares held by insiders; LEV = financial leverage proxy for the probability of financial distress, measured by the ratio of total debt to total assets; LIQ = proxy for the expected costs of financial distress, measured by the ratio of cash-flow to total assets; PE = proxy for growth opportunities, measured by the price earnings ratio; TAX = proxy for the convexity of firm tax schedule, measured by net operating losses to total assets; TI/TS = proxy for the need to hedge commodity price, measured by the ratio of total inventory to total sales. All accounting variables, with the exception of foreign firm sales, originate from the *Infinancials* database. Data on firm foreign sales and on hedging activities was manually collected from firm's annual reports. Data on inside ownership was collected from *Bloomberg* database and data on GDP originates from *World Economic Outlook* database *(International Monetary Fund)*.

[a] Estimation performed using OLS. [b] Estimation performed using Probit.

* Indicates values that the coefficients are significant at 10% or lower levels.

Table 5:
SUR and OLS/Probit Regression Results when Hedging Variable represents All Hedging Instruments

Independent variables	Dependent variables in the OLS/Probit regression						Dependent variables in the SUR regression						Predicted Influence
	$\|\beta_1\|$[a]	DUM_ALL[b]	$\|\beta_2\|$[a]	DUM_ALL[b]	$\|\beta_3\|$[a]	DUM_ALL[a]	$\|\beta_1\|$	DUM_ALL	$\|\beta_2\|$	DUM_ALL	$\|\beta_3\|$	DUM_ALL	
Const	2,680	-15,898					3,460	-2,978					
	(6,28)*	(-3,66)*					(8,20)*	(-3,40)*					
$\|\beta_1\|$		-0,021						-0,022					+
		(-0,56)						(-3,28)*					
FS/TS	-0,018						0,043						na
	(-0,03)						(0,07)						
DUM_ALL	-1,073						-1,995						-
	(-2,19)*						(-4,12)*						
Const			0,389	-16,555					0,433	-3,283			
			(5,11)*	(-3,79)*					(5,73)*	(-3,69)*			
$\|\beta_2\|$				0,042						-0,022			+
				(0,22)						(-0,56)			
LIQ			-0,089						-0,078				-
			(-0,34)						(-0,30)				
DUM_ALL			-0,063						-0,116				-
			(-0,79)						(-1,46)				
Const					0,329	-16,121					0,368	-3,181	
					(7,89)*	(-3,74)*					(8,90)*	(-3,62)*	
$\|\beta_3\|$						-0,180						-0,105	+
						(-0,51)						(-1,50)	
TI/TS					-0,010						-0,010		na
					(-0,68)						(-0,69)		
DUM_ALL					-0,053						-0,098		-
					(-1,18)						(-2,21)*		

(*continued*)

Table 5 (*continued*):

SUR and OLS/Probit Regression Results when Hedging Variable represents All Hedging Instruments

Independent variables	Dependent variables in the OLS/Probit regression						Dependent variables in the SUR regression						Predicted Influence
	$\|\beta_1\|$[a]	DUM_ALL[b]	$\|\beta_2\|$[a]	DUM_ALL[b]	$\|\beta_3\|$[a]	DUM_ALL[b]	$\|\beta_1\|$	DUM_ALL	$\|\beta_2\|$	DUM_ALL	$\|\beta_3\|$	DUM_ALL	
Control variables:													
ASSET		0,099		0,101		0,100		0,014		0,015		0,015	na
		(3,25)*		(3,28)*		(3,27)*		(3,12)*		(3,29)*		(3,23)*	
CAPEX		2,402		2,523		2,570		0,487		0,524		0,529	+
		(1,15)		(1,21)		(1,23)		(1,28)		(1,37)		(1,38)	
DIV		-3,856		-3,953		-3,978		-0,816		-0,843		-0,866	-
		(-0,84)		(-0,87)		(-0,87)		(-0,86)		(-0,88)		(-0,91)	
GDP		1,500		1,557		1,520		0,354		0,379		0,371	+
		(3,59)*		(3,71)*		(3,66)*		(4,17)*		(4,39)*		(4,37)*	
INS		-1,507		-1,497		-1,486		-0,295		-0,304		-0,298	+
		(-2,16)*		(-2,15)*		(-2,14)*		(-2,01)*		(-2,06)*		(-2,01)*	
LEV		1,374		1,441		1,484		0,201		0,219		0,223	+
		(1,90)*		(2,09)*		(2,12)*		(1,71)*		(1,86)*		(1,88)*	
PE		-0,004		-0,004		-0,004		-0,001		-0,001		-0,001	+
		(-0,85)		(-0,90)		(-0,91)		(-1,47)		(-1,57)		(-1,58)	
TAX		-0,573		-0,537		-0,507		-0,227		-0,220		-0,221	+
		(-0,39)		(-0,36)		(-0,34)		(-0,70)		(-0,68)		(-0,68)	
R^2	0,018	0,180	0,002	0,178	0,006	0,179	---		---		---		

Note. The statistics reported are obtained through Gretl (version 1.9.1). In the predicted influence column – na – means that there is no prediction. *t*-values are in parentheses. $|\beta_1|$, $|\beta_2|$ and $|\beta_3|$ represent the magnitude of exchange rate exposure, the magnitude of interest rate exposure and the magnitude of commodity price exposure, respectively; ASSET = proxy for firm size, measured by the natural logarithm of total assets; CAPEX = proxy for firm investment, measured by the ratio of capital expenditures to total assets; DIV = dividend yield proxy for firm liquidity, measured by the gross dividend per share divided by the closing stock price; *DUM_ALL is a* dummy which is assigned a value of 1 if a firm uses external and/or internal hedging instruments; FS/TS = proxy for firm foreign real operations, measured by the ratio of foreign sales to total sales; GDP = proxy for the availability of derivatives in capital markets, measured by the natural logarithm of gross national product per capita; INS = proxy for the managerial risk aversion, measured by the percentage of ordinary shares held by insiders; LEV = financial leverage proxy for the probability of financial distress, measured by the ratio of total debt to total assets; LIQ = proxy for the expected costs of financial distress, measured by the ratio of cash-flow to total assets; PE = proxy for growth opportunities, measured by the price earnings ratio; TAX = proxy for the convexity of firm tax schedule, measured by net operating losses to total assets; TI/TS = proxy for the need to hedge commodity price, measured by the ratio of total inventory to total sales. All accounting variables, with the exception of foreign firm sales, originate from the *Infinancials* database. Data on firm foreign sales and on hedging activities was manually collected from firm's annual reports. Data on inside ownership was collected from *Bloomberg* database and data on GDP originates from *World Economic Outlook* database *(International Monetary Fund)*.

[a] Estimation performed using OLS. [b] Estimation performed using Probit.

* Indicates values that the coefficients are significant at 10% or lower levels.

Appendix A:
Empirical evidence on financial price risk exposures and hedging

Panel A. Exchange rate exposure

Author(s) of study	Area of study	Country	Findings
Jorion (1990)	Measurement of exchange rate exposure and its determinants.	US	Only 5% of firms exhibited significant exchange rate exposure. Estimated exchange rate exposure increased as the firm's foreign involvement (measured by foreign sales) increased.
Jorion (1991)	Measurement of exchange rate exposure.	US	The returns of 20 value-weighted industry portfolios are shown to be insensitive to exchange rate changes.
Bodnar and Gentry (1993)	Measurement of exchange rate exposure and its determinants.	US, Japan and Canada	Eleven out of 39 two-digit industry portfolios exhibit significant exchange rate exposure. They notice, however, that export and import levels, reliance on internationally-priced outputs, product-type (traded or non-traded) and the degree of foreign assets help to determine exchange risk exposure at the industry level.
Amihud (1994)	Measurement of exchange rate exposure.	US	The authors find that there is no significant contemporaneous exposure, even for the portfolio composed of eight largest exporting companies where, on average, exports account for almost a quarter of their total sales.
Khoo (1994)	Measurement of exchange rate exposure	Australia	The sensitivity of stock returns to exchange rate movements, and proportion of stock returns explained by exchange rate movements are found to be small.
Bartov and Bodnar (1994)	Measurement of exchange rate exposure.	US	The results fail to find a significant correlation between the abnormal returns of the sample firms and contemporaneous change in the dollar.
Choi and Prasad (1995)	Measurement of exchange rate exposure and its determinants.	US	About 15% of the 409 firms in the sample have significant exchange rate sensitivities. Estimations revealed a positive relationship between the scope of the foreign operations of a firm – measured by foreign sales, assets and operating profits – and its exchange rate risk sensitivity.
Nydahl (1999)	Measurement of exchange rate exposure and its determinants, namely the impact of hedging.	Sweden	About 26% of the 47 firms in the sample are significantly exposed to exchange rate changes. It is shown that the level of foreign involvement significantly increases exposure, and that the use of derivatives decreases exposure.
He and Ng (1998)	Measurement of exchange rate exposure and its determinants.	Japan	About 25% of the 171 firms in the sample yield significant positive exposure coefficients and about 2% yield negative coefficients. Smaller firms and firms with weak short-term liquidity positions, or firms with high financial leverage, have more incentive to hedge and hence have smaller exchange-rate exposure.
Williamson (2001)	Measurement of exchange rate exposure and its determinants.	US and Japan	There is empirical evidence that automotive firms face exposure to exchange rate shocks. Evidence is presented that is consistent with foreign sales being a major determinant of exposure and the effectiveness of operational hedging in the form of foreign production.

(*continued*)

Appendix A (*continued*):
Empirical evidence on financial price risk exposures and hedging

***Panel A. Exchange rate exposure** (continued)*

Author(s) of study	Area of study	Country	Findings
Crabb (2002)	Measurement of exchange rate exposure, while controlling for the use of derivatives.	US	The results presented in this study show that the exchange rate exposure for large US multinationals is significant, but hedging activities by firm reduce such risk.
Nguyen and Faff (2003)	Analysis of both short-term and long-term exposure and impact of the use of derivatives on exchange rate exposure.	Australia	The results show that out of the full sample of 144 firms, only 10,34% have significantly monthly short-term exposure and 58,33% are significantly exposed for the 24 months' horizon. While both firm size and the use of financial hedging are associated with a reduction of short-term exchange rate exposure, the exposure of longer horizons is positively related to a firm's liquidity.
Hagelin and Pramborg (2004)	Foreign exchange risk reduction effect of hedging.	Sweden	About 24% of firms exhibited significant exchange rate exposure. Estimated exchange rate exposure increased with the level of inherent exposure and with firm's size. The evidence also suggests that the usage of foreign denominated debt as well as currency derivative reduce firms' foreign exchange exposure.
Bartram, Brown and Minton (2010)	Influence of both financial and operational hedges on foreign exchange exposure.	16 countries	This study shows that for a typical sample firm, pass-through and operational hedging, each, reduce exposure by 10% to 15% and financial hedging with foreign debt, and to lesser extent currency derivatives, decrease exposure by about 40%.

Panel B. Interest rate exposure

Author(s) of study	Area of study	Country	Findings
Sweeney and Warga (1986)	The pricing of interest rate risk.	US	The paper shows that, empirically, most of the interest rate sensitivity stocks are in the utility industries, and that there is evidence that the interest factor is priced in the same sense of the APT.
Bartram (2002)	Interest rate exposure and its determinants.	Germany	A significant interest rate exposure of nonfinancial corporations with regard to changes in the short-term and long-term riskless interest rate as well as the interest rate spread is reported. While many stocks show a significant linear interest rate exposure (e.g., for the short-term interest rate, 6,4% to 18,8% of firms), a large number of firms has an important nonlinear exposure component (e.g., for the short-term interest rate, 11,5% to 25,4% firms for the cubic function). In addition, there is evidence of a negative relationship between the interest rate exposure and measures of liquidity.

(*continued*)

Appendix A (*continued*):
Empirical evidence on financial price risk exposures and hedging

Panel C. Commodity price exposure

Author(s) of study	Area of study	Country	Findings
Tufano (1998)	Commodity price exposure and its determinants.	US	The estimation of the gold price exposure for the sample firms results in more than half of the firm-quarter exposures to be statistically significant. Those exposures are significantly negatively related to the firm's hedging and diversification activities and to gold prices and gold return volatility, and are positively related to firm's leverage.
Petersen and Thiagarajan (2000)	The impact of risk management strategies in firm's commodity price exposures.	US	The analysis of the gold price exposure of the companies American Barrick and Homestake Mining shows that financial and operative hedging, as well as financial and operative leverage, has an impact on the exposure of firm value with regard to the analysed factors.
Bartram (2005)	Commodity price exposure.	Germany	Even though commodity prices are more volatile, the fraction of sample firms with statistically significant commodity price exposure is, however, comparable to studies on foreign exchange exposure – roughly 4,5% to 15,9%. The results are consistent with few cash flows being affected by commodity price movements.
Carter, Rogers and Simkins (2006)	The effect of hedging in firm value.	US	The authors examine a monthly market model using an equally-weighted airline industry return that includes a jet fuel return factor to measure airline exposure to jet fuel prices. They find that airline industry stock prices are negatively related to jet fuel prices, namely one standard deviation movement in jet fuel price results in a 2,75% change (monthly) in airline industry stock prices.
Jin and Jorion (2006)	Firm value and hedging.	US	The study confirms that exposures to oil and gas prices are mostly positive and generally significant, so for the median firm, a 1% increase in oil(gas) prices leads to a 0,28% (0,41%) increase in the stock price. About 28,95% of the oil betas and 86,84% of the gas betas are significantly positive. Additionally, the authors find that hedging reduces the firm's stock price sensitivity to oil and gas prices and that greater oil and gas reserves increase it.

Panel D. All financial price exposures

Author(s) of study	Area of study	Country	Findings
Prasad and Rajan (1995)	Measurement of exchange rate and interest rate exposures.	Germany, Japan, UK and US	This study group's individual stock return data for Germany, Japan, The UK and The US equity markets into industry-based portfolios. The exchange rate risk and interest rate risk sensitivity in each of the four markets vary degrees, with the German and the US markets yielding a maximum number of industries with significant exchange rate exposure and Japan and Germany yielding the greatest number of industries with significant interest rate risk.
Bali, Hume and Martell (2007)	Interaction between firm's risk exposures, derivatives use and real operation.	US and Canada	Except for interest rates, there is little evidence that derivatives use reduces risk exposures. There is some evidence that user firms are increasing risk exposure in the use of commodity derivatives. Furthermore, the empirical results do not suggest a positive association between any of the variables for real operations and related exposures.

Appendix B:

Sample selection and country and industry composition

Panel A. Sample selection

Selection criterion	Sample size
Nonfinancial firms listed on Euronext belonging to the BAS Price, CAC All Shares, A-DAM All Shares and PSI General indexes, excluding cross listings	684
Firms with annual reports in English or Portuguese on their web sites	332
Firms with stock returns and complete accounting data on *Infinancials* database	311
Firms with inside ownership data on *Bloomberg* database	311
Firms with foreign sales and hedging data disclosed on annual report	304

Panel B. Country composition

Country	Obs.	% of sample
Belgium	71	23,4%
France	116	38,1%
The Netherlands	79	26,0%
Portugal	38	12,5%

Panel C. Industry composition

Industry	ICB industry codes	Obs.	% of sample
Oil and gas	0001	8	2,6%
Basic materials	1000	26	8,6%
Industrials	2000	84	27,6%
Consumer goods	3000	45	14,8%
Health care	4000	23	7,6%
Consumer services	5000	50	16,4%
Telecommunications	6000	6	2,0%
Utilities	7000	7	2,3%
Technology	9000	55	18,1%

Note. This table reports the effects of various sample selection criteria's (Panel A), country (Panel B) and industry (Panel C) composition for the sample of 304 nonfinancial firms. An annual report available in English or Portuguese on firm's web site is required for obtaining information about hedging policy and on foreign sales. Stock return and accounting data are required for calculating several inputs from the regression model. Finally, inside ownership data are from *Bloomberg* database which is required to test managerial risk aversion prediction, and data on GDP originates from *World Economic Outlook* database *(International Monetary Fund)* and proxy's for country financial market development. According to the Industry Classification Benchmark (ICB) classification codes in the *Infinancials* database, Panel C reports the firm's classification into industries for the final sample.