Risk Management Theory: A comprehensive empirical assessment

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Running head: RISK MANAGEMENT THEORY

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Working Paper

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Abstract

The aim of this paper is to develop a methodology for thorough empirical testing of major contemporary corporate risk management theories: financial theory, agency theory, stakeholder theory and new institutional economics. Unlike in previous research, the tests are organised around theories, rather than individual hypotheses. I used a number of tests for robustness and subjected hypotheses to repeated testing, cross-verifying results. Evidence of tests conducted on a sample of 150 companies listed at the Warsaw Stock Exchange in Poland, covering years from 2001 to 2005, clearly point to low empirical verification of all theories considered. However, I find evidence for some theoretical determinants: currency exposure, market-to-book value, IT and service sectors and size. In conclusion I suggest implications for future empirical and conceptual research.

Keywords: corporate risk management, hedging, derivatives, CART

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Working Paper

There have been many empirical studies aiming at finding support for the various theories of corporate financial risk management. However, subsequent research papers failed to determine which theories are supported by the data and which are not. In consequence both theoretical research efforts and the design of applied methods for corporate risk management are stalled by the inability to decide which theoretical approach to follow. After a spate of new research in this field in the late 90's there have been few studies that added to our understanding of corporate hedging behaviour. Incidentally, most valuable pieces of research in recent years concentrated on methodological issues: the endogeneity problem (Jin and Jorion, 2006), inclusion of non-derivative hedging (Davies et al., 2006; Judge, 2006), and assumptions about the purpose of derivative use (Faulkender, 2005). In this paper I follow the methodological strain of research and propose verification of risk management theory which is focused not on individual hypotheses but on theories. I also attempt to provide strong evidence as to the verification status of these theories by using a number of methods and subjecting hypotheses to repeated testing.

This paper aims to design and conduct an exhaustive empirical investigation into all major corporate risk management theories, which would provide strong statement of their verification status. The theories considered include risk management models developed within the body of the following theories of the firm: financial theory, agency theory, stakeholder theory and new institutional economics. Consequently, while most research papers present the hypotheses in sections concentrated around particular determinants of risk management, I discuss them in the order of theories from which they originated.

The inclusion of new institutional economics and stakeholder theory, none of which has been tested in the context of risk management, is the first attempt to introduce these theories to empirical research in the field. Both theories are relatively new and immature. However, since they offer a new perspective on the problem of hedging, it is worthwhile to consider them.

Another contribution of this paper is a cohesive testing methodology. First of all, I designed a set of hypotheses basing on previous research. Secondly, despite using a new approach to empirical verification, I strived to maintain comparability with previous studies in terms of hypotheses and statistical methods. Thirdly, I tested hypotheses using a wide range of statistical methods, with repeated testing of the same hypothesis, which provided double verification of results. These issues are discussed in the section on methodology below.

The choice of data also provides a new insight into risk management practices of companies. The dataset for this study comprises annual report data for 150 Polish listed companies, in the period of 2001-2005. Few studies of economic theories are carried out using emerging market data. In the period examined Polish companies had ready access to derivatives and were subject to International Accounting Standard 32 and 39 regulation. However only 30% used hedging, far fewer than in developed European or overseas markets. It is therefore interesting to investigate this new market and check if research results match those from different markets.

Theories and previous research

Financial economics approach

Financial economics approach to corporate risk management has so far been the most prolific in terms of both theoretical model extensions and empirical research. This approach builds upon classic Modigliani-Miller paradigm (Miller and Modigliani, 1958) which states

conditions for irrelevance of financial structure for corporate value. This paradigm was later extended to the field of risk management. This approach stipulates also that hedging leads to lower volatility of cash flow and therefore lower volatility of firm value. Rationales for corporate risk management were deduced from the irrelevance conditions and included: higher debt capacity (Miller and Modigliani, 1963), progressive tax rates, lower expected costs of bankruptcy (Smith and Stulz, 1985), securing internal financing (Froot et al., 1993), information asymmetries (Geczy et al., 1997) and comparative advantage in information (Stulz, 1996). The ultimate result of hedging, if it indeed is beneficial to the firm, should be higher value – a hedging premium.

Evidence to support the predictions of financial economics theory approach to risk management is poor. Although risk management does lead to lower variability of corporate value (e.g. Jin and Jorion, 2006), which is the main prerequisite for all other effects, there seems to be little proof of this being linked with benefits specified by the theory. One of the most widely cited papers by Tufano (1996) finds no evidence to support financial hypotheses, and concentrates on the influence of managerial preferences instead. On the other hand, the higher debt capacity hypothesis seems to be verified positively, as shown by Faff and Nguyen (2002), Graham and Rogers (2002) and Guay (1999). Internal financing hypothesis was positively verified by Guay (1999) and Geczy et al. (1997), while it was rejected by Faff and Guyen (2002) and Mian (1996). Judge (2006) found evidence in support of financial distress hypothesis. Tax hypothesis was verified positively by Nance, Smith and Smithson (1993), while other studies verified it negatively (Mian, 1996 ; Graham and Rogers, 2002). More recently Jin and Jorion (2006) provide strong evidence of lack of value relevance of hedging, although some previous studies have identified a hedging premium (Allayannis and Weston, 2001, Carter et al., 2006).

The hypotheses tested in this study include all of the above rationales, except for information asymmetries and comparative information advantage. The first two hypothesis test the underlying assumption, that hedging leads to lower volatility of company value.

Hypothesis 1a: There is a negative relationship between hedging and stock price volatility.

Hypothesis 1b: There is a negative relationship between hedging a particular risk and stock price exposure to that risk factor.

The next hypothesis tests for a hedging premium by looking at companies that start hedging, rather than a cross-section of hedgers vs. non-hedgers, following the approach of Guay (1999).

Hypothesis 1c: Firms that begin hedging experience a rise in market value of equity.

According to debt capacity and tax incentive rationales, firms should be interested in raising their gearing ratios, using the tax shield to the full extent, and lowering their tax charges. Hedging facilitates this by lowering risk of default and allowing higher debt capacity. Lower volatility of earnings may also result in lower average tax charges if the tax curve is concave, however in Poland corporate income tax is flat-rate so this effect is not important.

Hypothesis 1d: There is a positive relationship between hedging and debt/equity ratio.

Hypothesis 1e: Firms that begin hedging, raise their debt equity ratio subsequently.

Hypothesis 1f: Firms with low times interest earned ratio (EBIT/interest paid), but above one, hedge more often than either firms with high ratio or lower than one.

Hypothesis 1g: Firms that hedge are able to pay their interest charges (times interest earned ratio > 1).

Hypothesis 2h: There is a negative relationship between hedging and income tax paid (relative to sales).

Hypothesis 2i: Average tax charge falls after firms start to hedge.

The final hypothesis of financial economics is linked to securing internal financing for important strategic projects and lowering costs of financial distress. These incentives should be more important to companies with high development expenditure or other growth options.

Hypothesis 2j: There is a positive relationship between hedging and growth options, represented by high R&D expenditure or high market-to-book value ratio.

Agency theory

Agency theory extends the analysis of the firm to include separation of ownership and control, and managerial motivation. In the field of corporate risk management agency issues have been shown to influence managerial attitudes toward risk taking and hedging (Smith and Stulz, 1985). Theory also explains a possible mismatch of interest between shareholders, management and debt holders due to asymmetries in earning distribution, which can result in the firm taking too much risk or not engaging in positive net value projects (Mayers and Smith, 1987). Consequently, agency theory implies that defined hedging policies can have important influence on firm value (Fite and Pfleiderer, 1995). The latter hypotheses are associated with financing structure, and give predictions similar to financial theory.

Managerial motivation factors in implementation of corporate risk management have been empirically investigated in a few studies with a negative effect (Faff and Nguyen, 2002; MacCrimmon and Wehrung, 1990; Geczy et al., 1997). Notably, positive evidence was found however by Tufano (1996) in his analysis of the gold mining industry in the US. Financial policy hypotheses were tested in studies of the financial theory, since both theories give similar predictions in this respect. All in all, the bulk of empirical evidence seems to be against agency theory hypotheses however.

Agency theory provides strong support for hedging as a response to mismatch between menagerial incentives and shareholder interests. The following hypotheses are designed to test the basic implications of this theory. The first hypothesis tests if firms hedge

in order to decrease risk to block shareholders. The next three hypotheses address the question of hedging as a tool to safeguard debtholder interest and thus increase debt capacity. Unfortunately, due to data limitations I was unable to test managerial option and stock holding hypotheses.

Hypothesis 2a: There is a positive relationship between hedging and individual block ownership.

Hypothesis 2b: Hedging is used most often by companies with high debt/equity ratios.

Hypothesis 2c: Firms start hedging more often if they have low equity/assets ratios and wish to issue debt or take out a bank loan.

Hypothesis 2d: Firms start hedging more often if they have high debt/equity ratios and wish to issue debt or take out a bank loan.

New Institutional Economics

A different perspective on risk management is offered by new institutional economics. The focus is shifted here to governance processes and socio-economic institutions that guide these processes, as explained by Williamson (1998). Although no empirical studies of new institutional economics approach to risk management have been carried out so far, the theory offers an alternative explanation of corporate behavior. Namely, it predicts that risk management practices may be determined by institutions or accepted practice within a market or industry. Moreover, the theory links security with specific assets purchase (Williamson, 1987), which implies that risk management can be important in contracts which bind two sides without allowing diversification, such as large financing contract or close cooperation within a supply chain.

If institutional factors do play an important role in hedging, this should be observable in the data. First of all, there may be a difference between sectors. Secondly, hedging may be more popular in certain periods – in Poland one might venture a guess, that hedging should

become more popular with years. A more concrete implication of this theory, is that shareholders may be interested in attracting block ownership by reducing company risk. Here NIE is similar in its predictions to agency theory. However this theory also suggest that firm practices may be influenced by the ownership structure in general. These implications are tested with the following hypotheses.

Hypothesis 3a. There are differences in popularity of hedging between industries.

Hypothesis 3b: The frequency of hedging changes with time.

Hypothesis 3c: Hedging is positively related to individual block onwership.

Hypothesis 3d: Hedging behaviour is influenced by the ownership structure: the government, institutional investors, foreign investors.

Stakeholder theory

Stakeholder theory, developed originally by Freeman (1984) as a managerial instrument, has since evolved into a theory of the firm with high explanatory potential. Stakeholder theory focuses explicitly on an equilibrium of stakeholder interests as the main determinant of corporate policy. The most promising contribution to risk management is the extension of implicit contracts theory from employment to other contracts, including sales and financing (Cornell and Shapiro, 1987). In certain industries, particularly high-tech and services, consumer trust in the company being able to continue offering its services in the future can substantially contribute to company value. However, the value of these implicit claims is highly sensitive to expected costs of financial distress and bankruptcy. Since corporate risk management practices lead to a decrease in these expected costs, company value rises (Klimczak, 2005). Therefore stakeholder theory provides a new insight into possible rationale for risk management. However, it has not yet been tested directly. Investigations of financial distress hypothesis (Smith and Stulz, 1995) provide only indirect evidence (e.g. Judge, 2006).

I have designed the following hypotheses to test for the usefulness of this theory in risk management research. The first hypothesis addresses the importance of customer trust and resulting potentially high costs of financial distress in IT and service sectors. The second hypothesis also looks at financial distress costs, but in a general manner – companies with high intangible or human assets, and growth options are more sensitive to continuity problems. This is essentially the same as hypothesis 1j of financial economics. And finally, smaller firms are more prone to financial problems, which should increase their interest in risk management practices. The last hypothesis is however in clear contrast to all previous empirical evidence.

Hypothesis 4a: Hedging is more popular among firms form IT and service sectors.

Hypothesis 4b: Companies with high market-to-book value hedge more.

Hypothesis 4c: Hedging is more common among smaller firms.

Methodology

Since evidence in support of various risk management theories remains mixed I found there is a need to design a study, which will bring these theories together and test them on a single sample using robust methodology. This approach allows comparison of theories and their assumptions and can provide better indication of possible ways to develop new theoretical models. The sections below explains in detail the study design issues.

Data

Analysis was conducted on a panel of Polish non-financial companies, listed at the Warsaw Stock Exchange. The panel included data of some 150 companies (numbers for particular years varied slightly) for the period from 2001 to 2005. The last two years of the series were used for verification of results and data for this period was gathered from 30 companies selected randomly.

The choice of Polish listed companies for theory verification requires a comment, since there may be concerns about possible idiosyncratic factors influencing risk management in Poland. All companies included in the study were based in Poland, their ownership structure notwithstanding. My position is that verifying risk management theory on data from a country which is still developing can yield results as reliable as studies based on richest country data. Firstly, Polish companies have for the past 17 years been rapidly learning new business models and techniques, including financial management. Since I have based my study on the assumption of rationality I am of the opinion that Polish companies based their decision to implement risk management on an educated judgement of pros and cons. Secondly, due to ongoing economic transition there are fewer historical and institutional determinants of the current state of risk management in Poland than there might be in the USA, UK, or Germany. Thirdly, sufficient financial market infrastructure does exist in Poland for companies to engage in risk management. Consequently, Polish companies can implement financial risk management processes provided they find them useful.

The sample was further limited to include only non-financial corporations, that is companies from sectors other than financial services. This approach, adopted by Nance et al. (1993), Faff and Nguyen (2002) and Berkman and Bradbury (1996) is based on the premise that banks, insurance companies and other financial sector enterprises purchase and issue derivative instruments not only for hedging but also for trading purposes. Since both in these and in my study derivative instruments use is a proxy for hedging such companies had to be excluded from the sample.

When it comes to data collection two alternative approaches to risk management research are present in the literature: use of annual report data and questionnaires. In this study I selected the former option. Although it limits the selection of variables to the contents of official filings, data gathered using this approach are more reliable as they have been

prepared using transparent rules specified by regulation. In the case of Poland a new law based on IAS 39 was introduced in 2001, which regulated the disclosure of financial instruments, including hedging. Hence, the beginning of the series was set for the first reports prepared according to that regulation.

After reviewing variable distribution in the sample two largest companies were excluded as outliers. These were Telekomunikacja Polska S.A., the largest telecom provider, and PKN Orlen S.A., the largest oil refinement and distribution company. Both companies where incomparably larger than other companies in the sample and could not be analysed together with the rest of the market. Although both of them used hedging extensively, they would have to be analysed in a sample of large European companies, rather than Polish ones.

Variables

Choice of dependant variable for risk managements studies poses an important methodological problem: in this study I used a binary hedging proxy. I inspected manually annual reports of sample companies to determine whether a company used derivative instruments. If a company did disclose derivatives and did not state that they were used for speculation, I classified it as a hedger. This construction of the hedging variable is of course subject to justified criticism. Jin and Jorion (2006) suggest using delta measures, while Faulkender (2005) stresses the importance of first determining what derivatives are used for. Other authors point to the significance of non-derivative hedging (Judge 2006). Nevertheless the binary proxy method has appeared most often in risk management research for practical reasons. I decided to use this approach firstly to maintain comparability with previous research, and secondly, because it was impossible to determine objectively, basing on annual reports, what was the purpose of derivative use, as Polish companies refrain from using hedge accounting due to cumbersome regulatory requirements.

A detailed description of variables is show in Table 1. Exposure indicators were calculated for EUR/PLN, USD/PLN exchange rates and for WIBOR, EUR LIBOR, and USD LIBOR as betas in a CAPM style rates of return regression, following common practice in the field (e.g. Choi and Prasad, 1995; Bradley and Moles, 2001; Chen and So, 2002; Crabb, 2002). They were later changed to absolute values, as I was interested in the extent, not the direction of exposure. Sales revenue was used as a scaling variable, since all previous studies showed size to be a strong determinant of risk management practices. Industry coding was done in accordance with the general nomenclature of the Warsaw Stock Exchange.

Table 1. Description of variables

Symbol	Name	Symbol	Name
CURR	Total foreign currency denominated assets and liabilities	**investF**	Share of large foreign shareholders in equity (5% and above)
EQASS	Equity/Total assets ratio	**investGov**	Government's share in equity if above 5%.
expEIR	Exposure to euro Libor 3M interest rate	**investInd**	Share of block individual shareholders in equity (5% and above)
expEUR	Exposure to EUR/PLN exchange rate	**investInst**	Share of large institutional investors in equity (5% and above)
expUIR	Exposure to USD Libor 3M interest rate	**isssueE**	Cash inflow from issued equity
expUSD	Exposure to USD/PLN exchange rate	**issueD**	Cash inflow from issued debt
expWIR	Exposure to PLN Wibor 3M interest rate	**issueL**	Cash inflow from new loans
GEAR	Gearing - Debt/Equity ratio	**MTBV**	Market-to-book value of equity
GEAR_INT	Interest bearing gearing = Interest bearing debt/equity ratio	**MV**	Market Value of Equity
goalH	Binary variable set to TRUE if firm stated hedging as the goal of derivative trading	**RD**	R&D Expenditure - Cost of finished R&D projects
H	Binary hedging variable, set to TRUE if company disclosed derivative instruments	**riskComm**	Binary variable set to TRUE if company used commodity derivatives
INDUSTRY	Coded as: construction, chemical, timber products, machinery, energy, trade, IT, media, metal, construction materials, manufacturing, food, telecom, services	**riskFX**	Binary variable set to TRUE if company used currency derivatives
INTDEBT	Total interest bearing debt as percentage of sales	**riskIR**	Binary variable set to TRUE if company used interest rate derivatives
TIE	Times Interest Earned ratio	**TAX**	Corporate income tax as percentage of sales
SALES	Revenue from sales – proxy for firm size.	**VOL**	Stock price volatility – standard deviation of weekly rates of return

Results

The data was analysed using a number of techniques. All of the analysis was performed in R statistics package. In the first step I carried out tests of means and medians, as

is usually done in other studies of this field. The comparison was done in two ways: statically, by comparing hedgers to non-hedgers, and dynamically, by comparing companies that started to hedge in a given year with companies that did not hedge. I then proceeded to Hotelling's tests for difference of vectors of means, ANOVA, logit regression, and CART analysis. The last method, CART analysis, is in essence a decision tree method for breaking a sample into two categories using a series of decision nodes. It has not yet become popular in financial research, but as I will show below it has a number of advantages.

Table 2. Sample characteristics by year

		YEAR		
Variable	**Level**	**2001**	**2002**	**2003**
H	FALSE	92 (80%)	96 (70%)	110 (71%)
	TRUE	23 (20%)	41 (30%)	45 (29%)
goalH	FALSE	101 (88%)	112 (82%)	122 (79%)
	TRUE	14 (12%)	25 (18%)	33 (21%)
riskFX	FALSE	102 (89%)	111 (81%)	121 (78%)
	TRUE	13 (11%)	26 (19%)	34 (22%)
riskIR	FALSE	110 (96%)	127 (93%)	146 (94%)
	TRUE	5 (4%)	10 (7%)	9 (6%)
riskComm	FALSE	113 (98%)	134 (98%)	152 (98%)
	TRUE	2 (2%)	3 (2%)	3 (2%)
INDUSTRY	chemical	6	8	8
	clothing	5	5	5
	construction	20	21	21
	construction materials	5	5	5
	energy	2	2	3
	food	13	15	15
	IT	9	12	13
	machinery	13	13	13
	manufacturing	10	10	12
	media	4	4	6
	metal	10	12	13
	other	1	1	1
	pharmaceutical	1	1	1
	services	2	3	4
	telecom	7	7	8
	timber products	6	6	6
	trade	14	15	18
N		128	140	152

Univariate tests for the difference of means (table 3) indicated significant differences between hedgers and non-hedgers in size: hedgers tended to be larger both in terms of sales and market value of equity. This has been shown to be true in other markets by all previous studies and is a clear proof of barriers or strong economies of scale which must exist in

derivative hedging. However this result contradicts hypotheses 2a, 3c and 4c, all of which imply that smaller, more risky firms should benefit more from implementing hedging. Two other significant differences were in tax charges and individual block ownership. However, the sign in both cases was opposite to the predictions (hypotheses 1h, 2a and 3c). Comparisons of means between new hedgers and non-hedgers showed only two significant differences in the year 2002 for exposure to EUR/PLN exchange rates and WIBOR interest rate. In general tests in the dynamic approach provided widely varying results, both in terms of magnitude and sign.

Table 3. Test for the difference of means

	Difference of means hedgers vs. non-hedgers						**Difference of means new-hedgers vs. non-hedgers**			
	2001	2002	2003	2001	2002	2003	2002	2003	2002	2003
Variable	t	t	t	p	p	p	t	t	p	p
expEUR	0.0180	2.5834	-0.1537	0.9856	**0.0113**	0.8782	-2.2744	-0.9554	**0.0259**	0.3428
expUSD	-0.5256	-0.6075	-1.3748	0.6004	0.5449	0.1721	-0.3277	-0.7700	0.7441	0.4440
expWIR	-0.9926	1.0382	-1.1546	0.3233	0.3018	0.2508	-2.0848	0.6151	**0.0406**	0.5405
expEIR	-0.8514	-0.7575	-0.1073	0.3966	0.4506	0.9148	-0.1885	0.3703	0.8510	0.7123
expUIR	-0.9097	-0.8203	-0.6470	0.3652	0.4141	0.5190	0.1828	0.4755	0.8555	0.6359
VOL	0.6178	-1.0434	-3.4514	0.5382	0.2992	**0.0008**	0.6517	1.3707	0.5165	0.1746
MV	3.6763	4.5954	3.6292	**0.0004**	**0.0000**	**0.0004**	-1.5783	0.6075	0.1191	0.5453
GEAR	0.9471	0.2956	0.1180	0.3457	0.7680	0.9063	-0.6371	0.9379	0.5257	0.3506
GEAR_INT	-0.7300	1.1208	-0.8124	0.4678	0.2647	0.4180	-1.4435	0.3070	0.1543	0.7596
TIE	2.2236	0.8427	0.7208	**0.0283**	0.4009	0.4722	0.5877	-1.5730	0.5582	0.1190
TAX	2.0644	2.5592	1.4474	**0.0413**	**0.0116**	0.1500	-0.4571	-0.1017	0.6487	0.9192
SALES	3.1888	5.3829	4.8907	**0.0019**	**0.0000**	**0.0000**	-0.2053	-1.7967	0.8378	**0.0755**
RD	-0.4606	0.8245	-1.2929	0.6460	0.4111	0.1982	0.4636	0.3160	0.6441	0.7527
MTBV	1.1401	2.9285	1.5973	0.2573	**0.0042**	0.1127	0.0652	0.6282	0.9482	0.5318
investInd	-1.5693	-2.1544	-2.2676	0.1205	**0.0335**	**0.0251**	1.4484	1.3164	0.1529	0.1927
investGov	0.2401	-0.6103	0.2115	0.8108	0.5430	0.8328	0.7881	-0.2448	0.4337	0.8073
investInst	0.0327	0.4377	0.7159	0.9740	0.6625	0.4755	-1.0437	-1.3402	0.3009	0.1848
investF	-0.3465	1.6129	2.6686	0.7299	0.1097	**0.0086**	-1.6960	0.2546	0.0951	0.7998
EQASS	-0.0198	0.7804	0.6153	0.9842	0.4365	0.5393	-0.7609	1.3627	0.4487	0.1761
INTDEBT	-0.3724	1.1131	-0.6470	0.7107	0.2679	0.5187	-1.0659	0.3273	0.2909	0.7443
CURR	2.9863	0.8765	1.4949	**0.0035**	0.3823	0.1372	0.3259	0.2116	0.7453	0.8329
issueL	1.0551	-0.7811	0.7300	0.2937	0.4361	0.4666	0.7525	0.5594	0.4534	0.5772
issueD	-0.5606	-0.4794	-0.6001	0.5762	0.6324	0.5494	0.4256	0.3648	0.6713	0.7160
issueA	2.0399	-0.4955	-1.3467	**0.0438**	0.6210	0.1802	0.8009	0.9947	0.4250	0.3223

In bold: p-values below 0.1 and variables with significant p-values in two subsequent years.

Tests for the difference of medians (table 4) confirmed results of the previous test: size, tax charges and individual block holding were all significant again. However there were also other significant differences. Hedgers tended to have a higher median of foreign currency assets and liabilities, which would provide a clear reason for hedging. Moreover, they exhibited lower volatility of stock prices (hypothesis 1a) and higher market-to-book value (1j and 4b). Lower volatility is particularly important, as it shows that all other benefits arising form it can be attainable. Test of new hedgers vs. non-hedgers showed no significant differences here.

Table 4. Tests for the difference of medians.

	Difference of Medians hedgers vs. non-hedgers						**Difference of Medians new-hedgers vs. non-hedgers**			
	2001	2002	2003	2001	2002	2003	2002	2003	2002	2003
Variable	W*	W	W	p	p	p	W	W	p	p
expEUR	728	525.5	1150.5	0.3625	0.0000	0.4555	608.5	321	**0.0025**	0.4144
expUSD	837.5	901	1342	0.7679	0.3201	0.2665	465	321	0.2946	0.3249
expWIR	908	904.5	1370.5	0.2165	0.2632	0.1567	526	244	**0.0235**	0.5431
expEIR	884	1028	1305	0.3646	0.6198	0.6920	431.5	236	0.6645	0.4502
expUIR	840.5	980	1270	0.7116	1.0000	0.8148	394	250	0.9264	0.4882
VOL	812	1390	1996	0.9066	**0.0885**	**0.0002**	432	210	0.6519	0.1456
MV	435	519	988	**0.0064**	**0.0000**	**0.0000**	426	267	0.6265	0.5075
GEAR	1046	1915	2450	0.6864	0.8059	0.9233	701	270	0.6673	0.1023
GEAR_INT	437.5	1318	1929	0.4992	0.2467	0.4138	412	382.5	0.1171	0.1554
TIE	935	1617	1846	1.0000	0.0996	0.1476	625	392	0.8220	0.8811
TAX	675.5	1426	1993.5	**0.0175**	**0.0105**	0.3724	645	333	0.8396	0.3903
SALES	693	789	1243	**0.0250**	**0.0000**	**0.0000**	765	444	0.3353	0.6447
RD	1165	2299	3048	0.2376	0.1206	0.0177	786	316	0.2418	0.2866
MTBV	454	773	1503	**0.0135**	**0.0065**	0.1980	419	251	0.6209	0.4278
investInd	696	1613	2106	**0.0802**	**0.0280**	**0.0083**	197	138	0.0757	0.1310
investGov	571	1398	1658	0.9875	0.4342	0.7300	286	220.5	0.2954	1.0000
investInst	522	997	1421	0.7252	0.0557	0.2140	372.5	258	0.1323	0.3492
investF	550	1041	1461	0.9060	**0.0626**	**0.0399**	350	244.5	0.1513	0.8151
EQASS	1037	1917	2492	0.7352	0.8131	0.9483	699	247	0.6818	**0.0543**
INTDEBT	405.5	1465	2118	0.8276	0.7545	0.9804	362	367.5	0.4910	0.2381
CURR	712	1556	1915	**0.0558**	**0.0760**	0.2519	808	382	0.0852	0.8689
issueL	880	1881	1852	0.4681	0.6846	0.1494	959	483	0.5931	0.4478
issueD	1018	1713	1717	0.6752	**0.0349**	**0.0007**	970	391.5	0.3065	0.6526
issueA	1011.5	1693.5	2351	0.7366	0.0521	0.3046	962	319.5	0.4088	0.1741

*W stands for Mann-Whitney statistic. In bold: p-values below 0.1 and variables with significant p-values in two subsequent years.

Next, I tested for the multivariate difference of means using Hotelling's test for the difference of vectors of means. The logic behind this test is that while two groups may not exhibit strong differences in terms of individual factors, they may show differences in the combination of these factors. I first grouped hypotheses 1a, 1d, 1h and 1j of financial economics (which could be tested using this method), which produced a vector of means of following variables: volatility, gearing, tax charge, and market-to-book value. The statistic for years 2001-2003 was respectively 35.52, 74.08 and 86.30; in all cases much above the 5% confidence level mark of 10.048. Unfortunately one cannot tell from this result which factors were significant. By comparing this to univariate tests it can be seen that only the tax charge was significant, although with the wrong sign. Hypotheses 1c, 1e and 1i for the new-hedgers could not be tested using this method due to a singular covariance matrix.

Hotelling's test also gave positive results for hypotheses 2a and 2b of agency theory, with a score of 24.99, 34.98 and 33.13. However in this case the significant factor was block holding, which had a sign opposite to the predictions. It is therefore hard to determine whether this result is reliable, especially since the difference for gearing was inconclusive both in significance and sign.

Analysis of variance was a suitable method for testing hypotheses which required breaking the sample into more than two groups: hypotheses 1f, 1g, 2c, 2d, 3a-3d, and 4a. The first of these, hypothesis 1f, stated that hedging should be more popular among firms with low, but higher than one, times interest earned ratios. To test this, I divided the sample companies into three groups: ratio below one, ratio above one but below the median, and ratio above the median. There was however no significant difference between groups ($F=1.5067$ in 2001, 0.1588 in 2002 and 1.4844 in 2002). Hypothesis 1g stated that hedgers should be covering their interest expenses, so I assigned a dummy variable value 1 if this was true, and 0 if times interest earned ratio was below one. Results showed no significance,

except for 2002 at 8% level (F statistic for 2001-2003 was respectively: 0.0482, 3.1008, 0.8608).

Agency theory hypothesis 2c stated that companies motivated to hedging might be ones with low equity/total assets ratios which raise their gearing level subsequently. To test it I created two new variables: low equity/total asset ratio (split at the median) and rise in gearing (with two levels, 'increase' and 'decrease'). Results showed no significant differences for any of the factors or their interaction. The F statistic for 2002 ranged from 0.0341 to 0.4130. For 2003 I had to use Kruskal-Wallis test due to heterogeneity of variances – the result was 0.9917 (insignificant). Another agency theory hypothesis, 2d, focused on companies with high gearing that look to increase their debt capacity. There was however no significant difference for either 2002 or 2003, both for debt/equity ratio calculated using total debt and only interest bearing debt.

New institutional economics hypotheses concentrated on the role of trend, industry and ownership factors. Industry (3a) proved not to influence hedging, with F values of 0.8049, 0.3308 and 0.5968 for 2001-2003 respectively. Pooling companies into larger, more general industry groups did not help. There was also no significant difference between the time periods, as hypothesis 3b suggested (F=1.8981). However, testing for influence of ownership structure on hedging and starting hedging did yield some significant results (hypotheses 3c and 3d, table 5). For this analysis I converted ownership information was into dummy variables taking value 1 if a particular group of owners was present. Heterogeneity of variances was detected in 2001 data, so I calculated Kruskal-Wallis statistic for this and the following years, and they gave significant results. F statistics were significant in all three years for individual block ownership, although this was mostly due to significant negative correlation of this variable with firm size. Institutional ownership produced significant restult in 2002. Results for new-hedgers were poorer, with individual block ownership significant at

8% level in 2003 only, and the interaction with government ownership at 7% confidence level. Government ownership was also significant at 9% level in 2002. The final ANOVA test was for hypothesis 4a of stakeholder theory, which pointed to IT and service sectors as potentially more interested in risk management. However no significant difference was detected (F statistic: 1.9153, 0.5122, 0.3625).

Table 5. ANOVA results for ownership structure determinants of hedging.

	year					
	2001		**2002**		**2003**	
	st.*	p	st.	p	st.	p
Bartlett test	4,2168	**0,0400**	1,1952	0,2743	2,0040	0,1569
Kruskal-Wallis test	3,5919	**0,0580**	3,6511	**0,0560**	8,5951	**0,0034**
F-statistics:						
Individual	3,4719	**0,0668**	4,0195	**0,0478**	8,9237	**0,0035**
Government	0,2493	0,6192	2,2245	0,1392	0,3859	0,5358
Institutional	0,0201	0,8876	9,4659	**0,0027**	1,0529	0,3072
Foreign	0,0916	0,7631	0,5606	0,4559	0,0128	0,9103
Individual:Government**	0,1317	0,7178	0,1563	0,6935	0,2445	0,6220
Individual:Institutional**	1,0797	0,3025	0,4764	0,4917	3,1740	**0,0777**
Government:Institutional**	0,8827	0,3508	1,4556	0,2307	0,0068	0,9346
Individual:Foreign**	0,3454	0,5587	0,5181	0,4734	0,3488	0,5561
Government:Foreign**	0,8037	0,3732	0,0119	0,9134	0,0053	0,9420
Institutional:Foreign**	0,6033	0,4400	2,9234	**0,0906**	0,3704	0,5440

* st. stands for 'statistic', **interactions

Logit regression has also been used in similar studies, which motivated me to employ it in my analysis. However I decided not to pool all the variables together in one regression model, but rather create separate models for different theories. I created one equation for hedgers vs. non-hedgers hypotheses and another for new-hedgers vs. non-hedgers hypotheses of all the theories. I estimated the equations separately for each of the three years to compare stability of results – all significant variables maintained their sign and coefficient values changed only slightly, while insignificant variable coefficients varied widely. Table 6 shows results for equations estimated on 2002 data, which were consistently best in terms of significance, fit and prediction accuracy. All attempts to model new-hedgers vs. non-hedgers produced insignificant results. Hence, I did not provide a detailed table of results.

Two equations failed to produce any significant results: agency theory model, where hedging was to be correlated with individual block ownership and gearing, and new institutional economics equation, which focused on shareholder structure. Whereas NEI hypotheses were tested only as a pilot study, agency theory results are important, as I obtained negative results also in previous tests. Surprisingly, stakeholder theory model had two significant variables – MTBV and SALES – although the overall fit was low, and prediction accuracy poor. A much better result was obtained by financial economics model, where three variables were significant: expEUR, expUSD and MTBV. Two variables had signs opposite to expected: exposure to USD/PLN had a negative sign (exposure variables were in absolute values), and income tax had a positive coefficient.

To compare my results with previous studies I finally pooled all the variables together. I obtained a good fit with high prediction accuracy. The singificant variables were: exposure to USD and EUR rates, volatility, MTBV, IT and Services sector and size (sales). Predictions were quite accurate: 67% and 70% of correct hits, with 36% and 41% of false positives. The number of false positives could be decreased, although at the expense of positive hits, by estimating an equation with only the significant variables (table 6).

Table 6. Logit regression results for hedgers vs. non-hedgers (ITS stands for IT and Services industries).

Financial economics hypotheses

Variable	Estimate	z-value	Pr(>|z|)	
(Intercept)	-1,7681	-2,0470	0,0407	*
VOL	-12,1485	-0,9120	0,3615	
expEUR	1,7732	2,7760	0,0055	**
expUSD	-3,4439	-2,4670	0,0136	*
expWIR	6,5984	0,6040	0,5460	
GEAR_INT	0,8931	0,6620	0,5081	
TAX	23,2262	1,1140	0,2654	
MTBV	0,5539	2,0480	0,0406	*
Log-Likelihood	*-41,9079*			
	2001	*2002*	*2003*	
True Positives	*75,00%*	*81,48%*	*67,65%*	
False Positives	*36,73%*	*16,95%*	*47,83%*	

Stakeholder theory hypotheses

Variable	Estimate	z-value	Pr(>|z|)	
(Intercept)	-2,3930	-5,5020	0,0000	***
ITS	0,6685	1,0210	0,3074	
MTBV	0,5463	2,5510	0,0108	*
przychN	0,0000	3,3280	0,0009	***
Log-Likelihood	*-48,2389*			
	2001	*2002*	*2003*	
True Positives	*58,82%*	*64,71%*	*56,41%*	
False Positives	*52,31%*	*45,95%*	*48,15%*	

Best fit with mixed variables

Variable	Estimate	z-value	Pr(>|z|)	
(Intercept)	-1,1870	-1,4830	0,1381	
przychN	0,0000	3,5720	0,0004	***
ITS	3,2000	2,6170	0,0089	**
MTBV	0,3553	1,2400	0,2149	
VOL	-47,1800	-2,3870	0,0170	*
expEUR	1,3670	2,8860	0,0039	**
expUSD	-3,2940	-2,4170	0,0157	*
Log-Likelihood	*-34,1579*			
	2001	*2002*	*2003*	
True Positives	*40,00%*	*71,43%*	*52,94%*	
False Positives	*21,43%*	*19,12%*	*29,17%*	

Agency theory hypotheses

Variable	Estimate	z-value	Pr(>|z|)	
(Intercept)	-0,6648	-1,7110	0,0870	'
investInd	-1,5927	-1,9690	0,0489	*
GEAR_INT	0,8922	0,9140	0,3607	
Log-Likelihood	*-64,7657*			
	2001	*2002*	*2003*	
True Positives	*69,23%*	*71,43%*	*71,79%*	
False Positives	*56,25%*	*56,34%*	*50,00%*	

New Institutional Economics hypotheses

Variable	Estimate	z-value	Pr(>|z|)	
(Intercept)	-0,4128	-1,0500	0,2938	
investInd	-1,6343	-1,8270	0,0677	'
investGov	-2,0121	-1,1530	0,2490	
investInst	-0,2395	-0,2140	0,8304	
investF	0,7730	0,8810	0,3782	
Log-Likelihood	*-63,9055*			
	2001	*2002*	*2003*	
True Positives	*58,82%*	*64,71%*	*56,41%*	
False Positives	*52,31%*	*45,95%*	*48,15%*	

All variables

Variable	Estimate	z-value	Pr(>|z|)	
(Intercept)	-2,9200	-1,1650	0,2440	
CURR	1,2700	0,9230	0,3562	
expEUR	3,1410	2,3920	0,0168	*
expUSD	-5,6090	-2,2800	0,0226	*
expWIR	-3,9480	-0,1420	0,8871	
VOL	-59,9000	-1,9050	0,0568	'
GEAR_INT	0,2651	0,0770	0,9387	
TAX	33,7300	0,8570	0,3917	
MTBV	1,7050	1,8650	0,0622	'
investInd	-3,4780	-1,2970	0,1948	
investGov	-2,3950	-0,6300	0,5285	
EQASS	0,2696	0,0810	0,9352	
ITS	4,3300	1,8250	0,0679	'
SALES	0,0000	2,9810	0,0029	**
Log-Likelihood	*-17,5962*			
	2001	*2002*	*2003*	
True Positives	*66,67%*	*84,62%*	*70,00%*	
False Positives	*35,90%*	*12,00%*	*40,74%*	

The final method I used was the classification and regression trees (CART) algorithm for determining which of the factors suggested by theory provide best criteria for distinguishing hedgers from non-hedgers. This method, developed originally by Breiman et al. (1984), is an algorithm which produces a decision tree consisting of a hierarchy of criteria for splitting a sample into two groups. In the case of risk management CART models provide

a non-linear method for distinguishing hedgers from non-hedgers. It allows not only for non-linearity of relationships but also non-linearity of variables, sub-sample heterogeneity and existence of outliers. For example, CART can allow finding differences in hedging determinants between small and large companies, rather than mix the two together like other methods do. The algorithm takes all variables as input, unlike the logit method, and determines which provide best classification criteria. Estimated trees can then be tested using predictions for other periods or samples. I computed separate models for each of the three periods and then cross-verified. The following models were computed using *rpart* library.

There is one methodological note to be made here. CART models take one set of arbitrary parameters – cost of misclassification matrix – which can potentially influence the results. By default the matrix is set to equal costs for all errors. However, in this study I was interested in identifying hedgers, and it could be argued that there are some companies that don't hedge even though they do exhibit all the determining factors. This could warrant skewing the costs to low cost of false positive classification. I attempted recalculating the models using various settings of these costs. The results showed little improvement in accuracy, while the number of wrong positives rose dramatically. Consequently, I decided to use equal costs.

The algorithm produced quite different trees in the three periods, however two variables were used in all of them: sales (proxy for size) and industry. On top of that, in 2001 tax charge was used, in 2002 times interest earned ratio and exposure to EUR/PLN rate, while in 2003 it was volatility of stock price. Cross-verification results varied between 30% and 51% accuracy, and were consistently above the proportion of hedgers in the sample, which is the threshold above which we can say the algorithm produces significant results. The CART method failed totally however in distinguishing new-hedgers from non-hedgers, which was not a surprise, considering results of previous analyses.

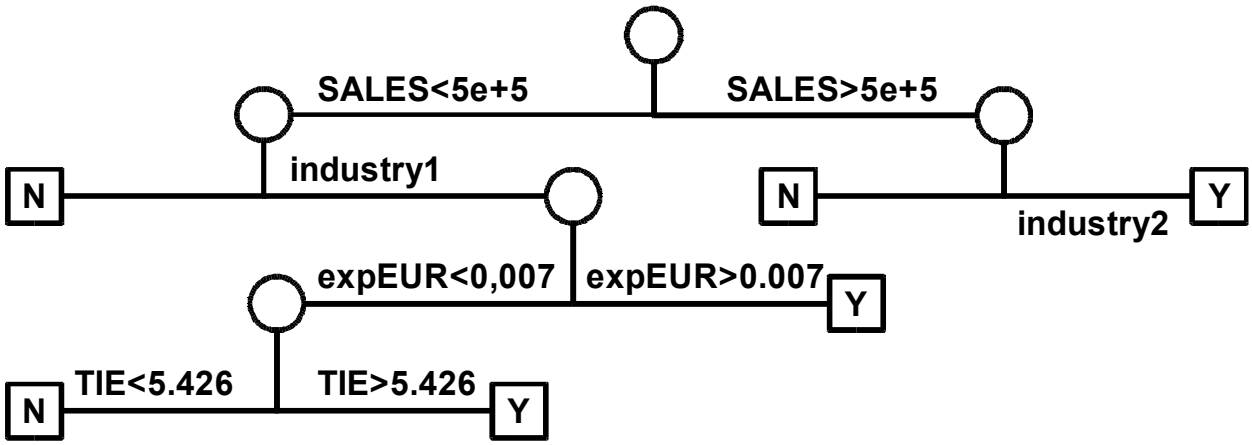

Fig. 1. Classification tree for hedgers (Y) vs. non-hedgers (N) based on 2002 data (industry1 stands for construction, timber products, machinery, energy, trade, IT, media, metal, clothing and services; industry2 stands for chemical, machinery, trade and food).

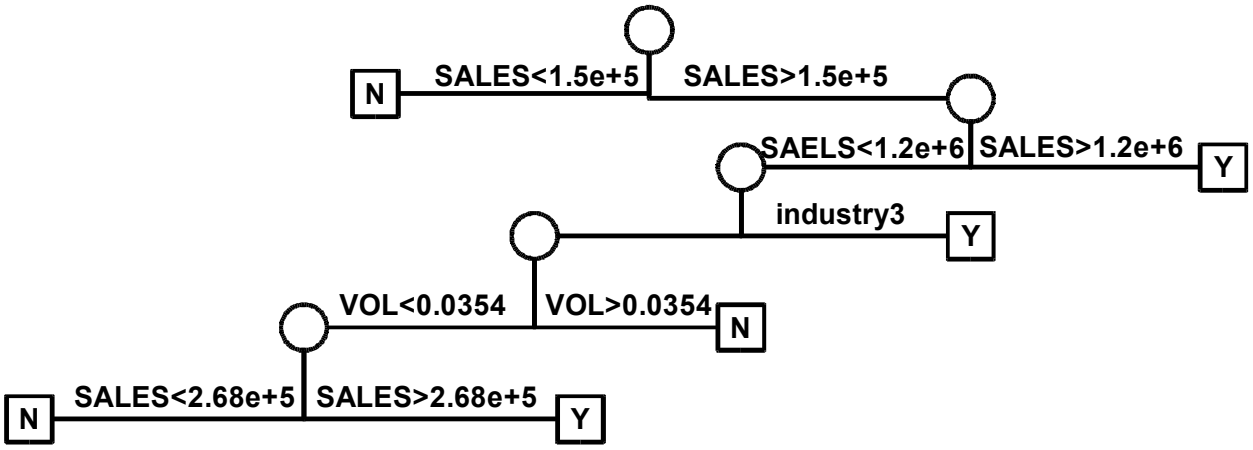

Fig. 2. Classification tree for hedgers (Y) vs. non-hedgers (N) based on 2003 data (industry3 stands for construction, machinery, trade, IT, construction materials, clothing, food, telecom, services and 'other')

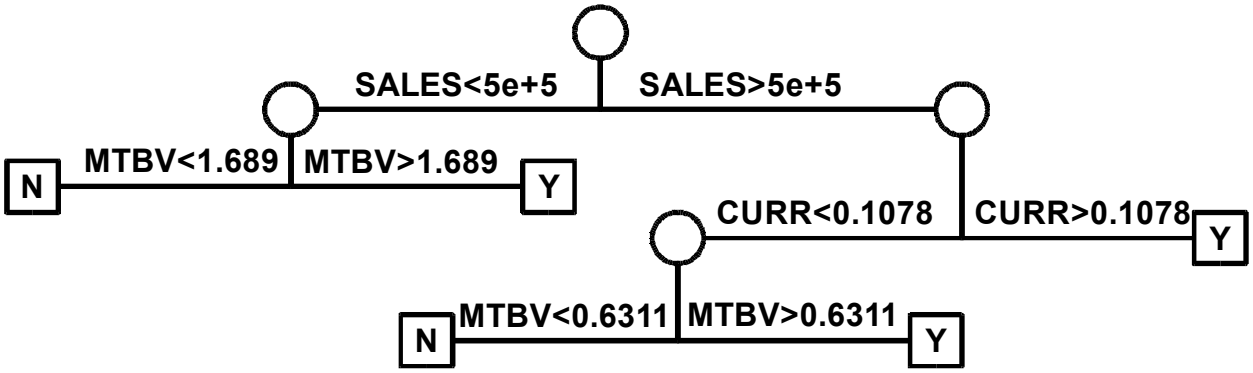

Fig. 3. Classification tree for hedgers (Y) vs. non-hedgers (N)on 2002 data, without INDUSTRY variable

Before interpreting the results, I first decided to drop the 2001 tree, which had lowest forecast accuracy (30%). The 2002 tree (accuracy of 39% for 2001 data and 51% for 2003, with false positives 23% and 22% of non-hedgers) used the industry variable twice: it was the criterion for selecting large companies that did hedge, and smaller companies that did not hedge. The other smaller companies were classified as hedgers if they had higher exposure to EUR/PLN rate or a very high level of times interest earned ratio (above 5.43). Although high exposure to exchange rate risk could be a determining factor, provided hedging does not remove it, the interest coverage was a surprise. It seems that hedgers were highly liquid and had no problems servicing their debt, which is contrary to hypotheses 1f and 1g.

The 2003 tree (accuracy of 43% and 44%, false positives 20% and 17%) started by classifying all companies with sales lower than 150.881 million PLN as non-hedgers, while all companies larger than 1.2 billion PLN were classified as hedgers. Of the ones in between the industry determined classification of hedgers in the first step, while other companies were classified as hedgers only if they had low volatility of stock price (below 0.0354) and sales higher than 268 million PLN.

To refine the decision trees I decided to compute them again without the industry variable. Although this variable was indicated by new institutional economics as a possibly determining factor (3a), there was a risk, that results are influenced by low number of companies in some sectors (Table 2). The new trees were quite different from the previous ones, but maintained the same level of accuracy. I discarded the 2003 tree, because it was too branched, which made interpretation difficult, and achieved lower accuracy (39% and 41% positive hits, 21% and 11% false positives) than the 2002 tree (48% and 53%, with 19% and 29% false positives). The 2002 tree took two new variables: total foreign currency assets and liabilities, and market-to-book value. Among smaller companies hedgers were identified as having MTBV ratio above 1.689 – result in line with hypotheses 1j and 4b. Large companies

were classified as hedgers if they had total currency assets and liabilities of above 10.78% of annual sales or MTBV above 0.6311. The first criterion is definitely logical, as it indicates greater exposure, while the second is again in support of theory. Although it has to be noted, that MTBV below one cannot be referred to as high.

Results of all analyses were verified by computing the tests again on a random sample of 30 companies for the years 2004 and 2005. Tests of means and medians produced similar results in terms of the signs of difference, though fewer variables showed statistically significant differences. This was to be expected in a smaller sample, and thus I accepted consistent signs of difference as supporting evidence. Tests of medians produced no significant differences at all. Hotelling's test for hypotheses 1a, 1d, 1h and 1j of financial economics confirmed significant difference. The other set of financial hypothesis could not be tested due to covariance matrix singularity. The test for agency theory's hypotheses 2a and 2b showed no significance. Analysis of variance tests confirmed previous results, however industry and ownership hypotheses could not be verified due to low number of observations in groups.

Predictions for 2004 and 2005 of logit models that produced significant results were accurate at 46%-62% level with false positives ratio ranging between 14% and 31%. As in previous tests, it was the pooled-variables model that attained best results. CART decision trees maintained their level of accuracy in predictions. The 2002 and 2003 trees with industry variables correctly identified between one third and 44% of hedgers with 0%-23% of false positives. The refined 2002 tree achieved accuracy of 55% and 57%, though the number of false positives was high: 44% and 22% respectively.

Discussion

Results described above clearly show that only selected few of the determinants indicated by the theories were supported by the data. Out of all financial economics

hypotheses I found evidence for only 1a (lower volatility) and 1j (growth options) hypotheses. None of agency theory hypotheses proved helpful in identifying determinants of hedging. The two new approaches, stakeholder and new institutional economics, which were tested here did provide some potentially useful insights: hypotheses 3a (industry factors), 4a (IT and services sector), and 4b (intangible assets) were positively verified. In addition I found that three variables were significant as well: size of the company (+), exposure to EUR/PLN rate (+), and foreign currency assets and liabilities as percentage of sales (+). Finally, my attempts to verify determinants of starting hedging failed, and therefore provide no basis for discussion.

A closer look at the hypotheses which were positively verified makes it apparent that hypotheses 4b and 1j were tested using the same variable – market-to-book value. Although I tried to verify hypothesis 1j using two other variables: R&D expenditure and capital expenditure, none of these proved significant and both had negative coefficients in logit models. Hence, a question arises if the significance of MTBV variable supports the internal financing hypothesis 1j, or intangible assets hypothesis 4b. The insignificance of other measures of growth options and evidence provided in other studies in support of costs of financial distress (Judge, 2006) hypotheses seem to point to the latter hypothesis.

The conclusion of low empirical verification of the theories may be questioned on methodological grounds. In fact, there is a number of problems in empirical analysis of risk management. Firstly, it may be argued that the sample does not allow generalisations. However, this argument does not stand to closer inspection. The discipline of economics assumes that all people and organisations are, at least limitedly, rational, no matter in which market they act. With the exception of new institutional economics, none of the theories under investigation make any inferences as to cultural or country differences. Moreover, results match those from previous studies surveyed in the second section of this paper.

Secondly, cross-industry sample studies suffer from endogeneity issues (Jin, Jorion, 2006). We can never be sure that a significant correlation is not in fact spurious, related to a third factor. For this reason I included dynamic hypotheses and tested for determinants of starting hedging in my study, following Guay (1999), although without significant results. I also included industry variables, which proved to be significant.

Thirdly, the reader might question, why I did not use panel regression in logit estimation, rather then estimate separate models for each year. There were two reasons for this. Firstly, ANOVA tests showed no significant difference in hedging activity between the periods. Secondly, I wanted to cross-verify results by running predictions from the estimated equations on the rest of data, as exhibited in table 6.

Finally, the very concept of negative or low verification may be called into question. After all most studies focus on finding empirical support for theories, and either succeed or not, without drawing conclusions as to the usefulness of tested theories. This problem has been extensively discussed in the past, with arguments ranging from popperian falsification (Popper, 1959), to neo-classical non-falsification (e.g. Machlup, 1967). My position on this issue is that although we need to be careful before we discard a theory, critical testing of theories and their assumptions is essential to research progress. This study does not stand alone in exhibiting the shortcomings of present theories, but has been preceded by over a decade of empirical research which points clearly to low verification of theories in question. Moreover, the aim of this study is not to suggest discarding the theories but to bring the theories together, test them in a systematic fashion and identify possibilities for further conceptual research in this area.

Conclusion

This paper investigated main theories of risk management: financial economics, agency theory, stakeholder theory and new institutional economics. Results have shown that

financial economics and agency theory hypothesis found little supporting evidence, while the two recent approaches, stakeholder and NEI may be offering new insights into the determinants of risk management. The poor results clearly indicate that there must be other significant factors, not included in present theories. Further research will be needed to identify these factors, and later incorporate them into a comprehensive theoretical model which will explain risk management practices of firms better.

Results point to practical considerations as main determinants of risk management: firms were found to be hedging in response to foreign currency exposure, and it was mostly large firms. This implies that managers considering implementation of financial risk management should first look at their direct exposures,and consider what other companies in the market are doing rather than analyse the problem along the lines of theory.

Future research may focus on these practical reasons and their implications for corporate value. On the other hand, hedging is linked to stock volatility and market value. The question remains as to the causal relationship between this variables. There is a needed to depart from the eclectic approach to risk management theory and attempt construction of a new, comprehensive theoretical model, which would cover all of the empirically identified determinants of risk management.

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