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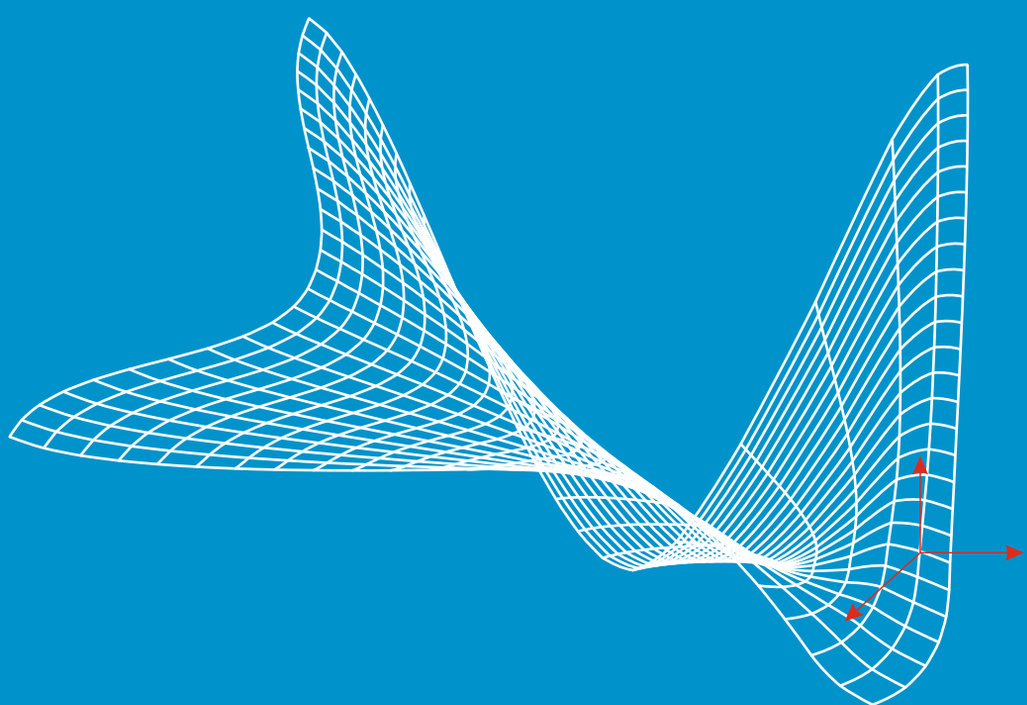

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Editorial board

Contact: Johannes (Joost) Platje, johannes.platje@wroclaw.merito.pl, ul. Fabryczna 29-31, 53-609 Wrocław, Poland

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The relationship between global oil prices and the profitability of Dutch public companies

Wim WESTERMAN, Luuk ENSING

Rijksuniversiteit Groningen, The Netherlands

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Aim: This study honors the pioneering work by André Dorsman on energy finance, especially on oil prices and company performance. The objective is to investigate the relationship between the global oil price and the profitability of Dutch companies.

Design / Research methods: In our research, a model is formed which evaluates the relationship between a global oil price index and the profitability of Dutch public companies. Publicly available data from 143 Dutch listed firms during the period 2010 till 2023 has been used to conduct this research. Besides the independent variable (the oil price) and the dependent variables (return on assets and return on equity), a firm's leverage, market capitalization and degree of internationalization are used as control variables in the conceptual model. The model is evaluated via multiple panel regression analyses.

Conclusions / findings: We reveal a positive relationship between the oil price and the return on assets as well as the return on equity. However, this relationship is dependent upon the presence of oil and energy related companies in the sample. When oil and energy related companies are removed from the sample, no relationship is found between the global oil price and profitability. The control variable market capitalization is found to be significant and positively related to return on equity and return on assets. Contrary, the control variable leverage is found to be negatively related to return on assets. The variable for degree of internationalization of Dutch firms is insignificant for all the regression models, indicating that there is no linear relationship between the degree of internationalization and profitability.

Originality / value of the article: The study confirms a complicated relationship between oil prices and company profitability.

Keywords: oil price, profitability, Dutch companies
JEL Codes: G10, L95

Correspondence address: Wim WESTERMAN, Rijksuniversiteit Groningen, Faculty of Economics & Business, Nettelbosje 2, 9747 AE Groningen, The Netherlands, The Netherlands. E-mail: w.westerman@rug.nl.

1. Introduction

This study honors the pioneering work of André Dorsman in the practice and scholarly field of energy economics and finance, both in in the Netherlands and way beyond, as the long-term President of the Center for Energy Economics and Value Issues (CEVI).

Our research paper investigates the relationship between the global oil price and the profitability of Dutch companies. Oil, also known as crude oil or petroleum is a liquid naturally formed in certain geographical locations. The product is used for many applications such as transportation, heating, food production and cosmetics. The versatility and frequency of use of the product causes oil to be a determinant of economic growth (Hanabusa 2009).

Oil is sold in the form of barrels in the global commodity market. The price per barrel is determined by supply and demand conditions. The supply of oil is mostly controlled by a small number of countries, these countries are participating in, or aligning with, the so-called OPEC(+) cartel. The Organization for Petroleum Exporting Countries controls around 40% of the global oil supply. These countries organize meetings to determine the cumulative oil supply. The supply decisions made in the OPEC(+) meetings change the price per barrel. The demand for oil is more fluent and can move due to changes in factors such as: economic growth, energy consumption and geopolitical.

Since oil is used for such a variety of applications, the price of oil influences the costs companies make. Most frequent expenses include transportation costs and manufacturing costs, but oil also changes other business expenses. Therefore, it is expected that oil prices change the profitability of companies.

Research has indicated that a higher oil price results in more profit for companies in the oil & gas industry (Dayanandan, Donker 2011). Despite the lack of oil exports in the Netherlands—the Netherlands imported 98 million tons of oil in 2020 and during the same year there were no exports, there are still 12 companies included in the sample of this research paper, which are in the oil and/or energy sector.

Given the fact that The Netherlands has no oil exports, it is expected that Dutch business are negatively affected by higher oil prices since their business expenses will

increase. Nevertheless, it should be noted that a high oil price is the effect of a high demand, supply, or both. Moreover, generally, a high oil demand is associated with much economic activity.

Considering that there is no dominant paradigm on the effect of the oil price on the Dutch economy, this paper seeks to provide answers to the question: *'How does the global oil price relate to the profitability of Dutch public companies?'.* Company managers can use the results provided to support their profitability forecasts, and ultimately to be better informed about the effects of the oil price on the Dutch economy.

With the aim of answering the research question, a conceptual model was formed. The model relates the effects of oil prices (independent variable), firm size (control variable), leverage (control variable), and degree of internationalization (control variable) to the profitability (dependent variable) of Dutch companies.

The sample used includes 143 public companies with their headquarters located in the Netherlands. Yearly data from the period 2010–2022 is used. The company specific data (firm size, leverage, degree of internationalization and profitability) is sourced via Eikon Refinitiv. The oil price is sourced from the OPEC reference basket, ORB (https://www.opec.org/opec_web/en/data_graphs/40.htm). This index is made up of the Saharan Blend (Algeria), Djeno (Congo), Zafiro (Equatorial Guinea), Rabi Light (Gabon), Iran Heavy (Islamic Republic of Iran), Basra Medium (Iraq), Kuwait Export (Kuwait), Es Sider (Libya), Bonny Light (Nigeria), Arab Light (Saudi Arabia), Murban (UAE) and Merey (Venezuela).

Since the data is likely affected by heteroscedasticity and autocorrelation problems, the conceptual model is tested via a GLS (generalized least squares) estimator instead of the OLS (ordinary least squares) method. A fixed effects and random effects model are performed, whereafter a Hausman test is performed to evaluate which model can best evaluate the data. Thereafter, the effect of the oil price on the return of equity is measured. Finally, two fixed effects regressions are performed. The regressions are on a sample excluding the oil and energy companies while the second sample excludes all companies except those in the oil and energy sector.

A detailed description of the available literature can be found in the literature review in section 2. The descriptive statistics and research design are explained in the methodology section (3). The regression results can be found in the findings (section 4). The discussion of the findings is provided in section 5. The conclusion of the research follows in section 6. Finally, limitations and recommendations are given (section 7).

2. Literature review

The literature review is based upon peer-reviewed articles published by renowned journals. In total, 11 major articles have helped to develop this research. A summary of these articles is available upon request. In this literature review, a selection of three main articles has been made. The articles helped to define and select the independent variables. Additionally, the articles provided a base for forming the tested hypotheses.

The available literature on the topic can be categorized in two broad categories: oil, and profitability. Naturally, academic articles combining the two topics are most relevant. Despite their relevance, there seems to be a lack of articles combining oil and profitability. More commonly, the relationship between oil and economic factors such as growth and inflation are studied.

2.1. Oil price

The independent variable (the oil price) is often measured as the WTI (West Texas Intermediate) oil price or the Brent Crude oil price. Selecting one of the two, or the wrong price indicator, can lead to decreased reliability of the research. The wrong price indicator can be selected, or more commonly, the price indicator selected does not (completely) represent the variable.

The paper *The oil price does not exist* (Original title in Dutch: *'De' olieprijs bestaat niet*) written by André Dorsman, Jerry de Leeuw and Ranjit Nelissen (2008) helps to define the variable 'oil price'. The authors of the paper note that there is not a single oil price. There are different oil prices based upon different qualities of oil and geographic areas. The authors recommend using an index, combining different

oil prices, to correctly measure the variable. We pick up this notion by using the OPEC-index ORB.

2.2. Hypothesis formation

Understanding the relationship between the oil price and economic factors can help to develop a hypothesis regarding the nature of the effect. Does a higher oil price cause profitability to grow or to decline?

In the paper *The Impact of International Oil Price Fluctuation on China's Economy* written by Zhang Qianqian (2011), the author studies the effect of oil price fluctuations on China's economy. The research establishes that the oil price is negatively correlated with net exports and real output. Additionally, the author finds evidence for a positive link between oil prices and inflation.

Concluding from the findings in the study by Qianqian (2011), it is expected that a higher oil price is bad for the real output and net exports of the Netherlands. Moreover, a higher oil price would cause inflation to be higher. All three causations found have bad implications for the profitability of companies.

The findings from *Oil prices and profitability performance: sector analysis*, written by Woraphon Wattanatorn and Termkiat Kanchanapoom (2012), illustrate an opposing view. In this paper, the authors have used data from the Thailand stock exchange. The findings suggest that during the period between 2001 and 2010 the oil price has had a positive impact on the profitability of companies in the energy and food sectors. The study focusses on other sectors to, but no significant effects were found.

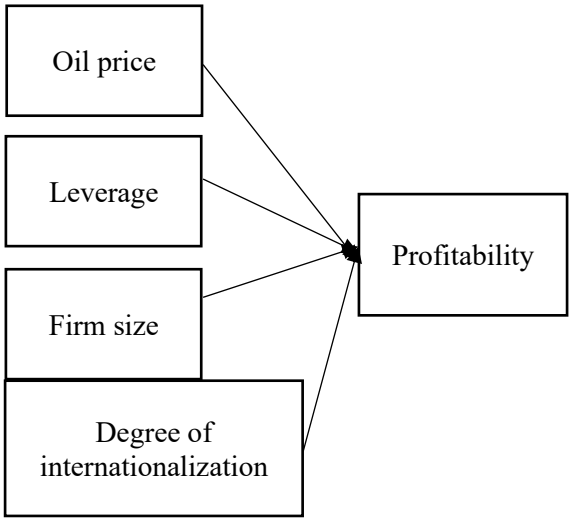
The two papers illustrate conflicting effects of oil prices. While in the paper authored by Qianqian (2011) negative effects of a high oil price are shown, the paper by Wattanatorn and Kanchanapoom (2012) finds that a high oil price has a significant positive effect on the profitability of some industry sectors.

The opposing effects have helped with forming the following set of hypotheses:
H0: There is no relationship between oil prices and profitability.
H1: There is a relationship between oil prices and profitability for companies in the oil & energy sector.
H2: There is a relationship between oil prices and profitability.

3. Methodology

Based on the literature review, a conceptual model (see Figure 1) was made to investigate the relationship between oil prices and profitability in the sample.

Figure 1. Conceptual model



Source: own elaborations.

3.1. The data

The variable specifications are given in Table 1 below. Control variables help to define the relationship between the oil price and profitability. Leverage, size and degree of internationalization are chosen as control variables.

In total, four regressions are performed on the whole sample and two regressions are performed on a subset. The whole sample includes all (143) public companies headquartered in the Netherlands. The two regressions on the partial dataset divide the sample into two groups. One regression includes all oil and energy related companies (12) and the other one excludes these (131). The sample data excludes funds and is solely focused on companies with ordinary shares. Yearly datapoints during the period 2010–2022 are used as the regression input. The firm specific data (leverage, firm size, degree of internationalization and profitability) is sourced via

Refinitiv Eikon. The oil price is sourced via the ORB (OPEC Reference Basket), an index combined of different oil prices denoted in dollars per barrel. Since the dataset covers multiple variables over a 12-year period, the data is categorized as panel / longitudinal. Panel data is likely to have heteroscedasticity and autocorrelation problems. Therefore, the GLS (generalized least squares) estimator is used here.

Table 1. Specification of variables

Independent variables	**Measurement form**	**Formula**
Profitability	Return on assets is used as the main measure for profitability.	$ROA = \frac{Net\ income + interest\ expense}{Total\ assets}$
	Return on equity is used to confirm the main measurement for profitability.	$ROE = \frac{Net\ income}{Shareholders\ equity}$
Dependent variable:		
Oil price	The OPEC basket price is used. The OPEC basket price is an index composed of different oil prices denoted in dollars per barrel of oil.	
Control variables:		
Firm size	Market capitalization is used as the measure for firm size. Market capitalization is measured in dollars.	$Market\ capitalization = Total\ shares * shareprice$
Degree of internationalization	Total foreign sales in relation to total sales is used as the measure for the degree of internationalization.	$\%\ of\ foreign\ sales = \frac{Foreign\ sales}{Total\ sales}$
Leverage	The debt to equity equation is used to measure leverage.	$Leverage = \frac{Total\ debt}{Total\ equity}$

Source: own elaborations.

3.2. Outliers

Boxplots were made to examine the raw data distribution. The boxplots illustrated that the raw data contained many outliers. The outliers in the dataset generated from Refinitiv Eikon were compared to reported data in the income statements and annual reports of the companies and if needed replaced by the latter.

The descriptive statistics in Table 2 below indicate that the data on: return on assets, return on equity, market capitalization and leverage do not follow a normal

distribution. Nevertheless, data on the oil price and percent of foreign sales nearly follow a normal distribution.

To decrease the skewness and kurtosis of the market capitalization and leverage variables, the natural logarithm of the variables is used in the regressions. For the independent variables (return on assets and return on equity), no adjustments were made. The skewness and kurtosis cannot be decreased by forming a natural logarithms of the variables since the datapoints of the variables are dual-signed (negative and positive).

Table 2. Descriptive statistics

Variable	Number of observations	Skewness	Kurtosis	Median	Min	Max
Return on assets	1,327	-4.7	33.07	2.11	-254.57	64.23
Return on equity	962	-2.61	73.71	0.10	-22.35	19.53
Oil price	13	0.03	1.52	69.89	40.76	109.45
Market capitalization	1,338	7.99	93.42	547 million	10.53	327 million
Ln (market capitalization)	**1,338**	**-0.74**	**4.25**	**20.12**	**2.35**	**26.51**
Leverage	1,190	4.36	29.47	59.98	0	1397.99
Ln (leverage)	**1,190**	**-1.73**	**8.43**	**4.14**	**-3.91**	**7.24**
Percent foreign sales	805	-0.56	2.43	66.76	0.08	100
Bold variables represent the normal variables transformed to a natural logarithm.						

Source: own elaborations.

A correlation matrix was made to understand the correlations between the variables. The matrix shows that there is no correlation greater than |0.3| indicating that there is no severe multicollinearity between the dependent variables. Furthermore, the matrix indicates that most correlations are not apparent, while some are weak.

3.4. Research design

To test the hypotheses according to the conceptual model, six regression models are formed.

3.4.1. Abbreviations used in the model equations:

$\beta =$ the coefficient for the variables.
$\alpha_1 =$ represents the intercept.
$v_i =$ represents the firms random effects.
$i =$ reprensents the different firms.
$t =$ reprensents the different years.

3.4.2. Model 1

Model 1 measures the effect of the oil price on the return on assets. The model used is a fixed effects model:

$$Return\ on\ assets_{it} = \alpha_{1i} + \beta_1 * Oil\ price_{it} + \beta_2 * \ln(Market\ capitalization_{it}) + \beta_3 * \ln\left(\frac{Debt}{Equity}_{it}\right) + \beta_4 * \frac{Foreign\ sales}{Total\ sales}_{it} + \varepsilon_{it}$$

3.4.3. Model 2

Model 2 measures the effect of the oil price on the return on assets: The model used is a random effects model:

$$Return\ on\ assets_{it} = \alpha_1 + \beta_1 * Oil\ price_t + \beta_2 * \ln(Market\ capitalization_t) + \beta_3 * \ln\left(\frac{Debt}{Equity}_t\right) + \beta_4 * \frac{Foreign\ sales}{Total\ sales}_t + v_i + \varepsilon_{it}$$

3.4.4. Hausman test

To test whether the fixed or random effects model is more representative for the sample, a Hausman test is performed.

3.4.5. Model 3

In model three, the internationalization variable is included as a dummy. The dummy variable is constructed so that:

$Dummy\ is\ 0\ when$:
$$\frac{Foreign\ sales}{Total\ sales} \leq 0.5$$

$Dummy\ is\ 1\ when$:
$$\frac{Foreign\ sales}{Total\ sales} > 0.5$$

The regression equation used is similar to the fixed effects model:

$$Return\ on\ assets_{it} = \alpha_{1i} + \beta_1 * Oil\ price_{it} + \beta_2 * \ln(Market\ capitalization_{it}) + \beta_3 * \ln\left(\frac{Debt}{Equity}_{it}\right) + \beta_4 * Dummy_{it} + \varepsilon_{it}$$

3.4.6. Model 4

Model 4 uses the same independent and control variables as the other models. However, model 4 includes a different independent variable. In model 4 the effect of the oil price on the return on equity is measured. Testing the independent and control variables on a diffferent measure for profitability increases the external validity of the research. Additionally, this will help to verify and define the relations found in the models using the independent variable return on assets. Model 4 uses a fixed effects regression:

$$Return\ on\ equity_{it} = \alpha_{1i} + \beta_1 * Oil\ price_{it} + \beta_2 * \ln(Market\ capitalization_{it}) + \beta_3 * \ln\left(\frac{Debt}{Equity}_{it}\right) + \beta_4 * \frac{Foreign\ sales}{Total\ sales}_{it} + \varepsilon_{it}$$

3.4.7. Model 5 & 6

Models 5 and 6 use the same regression model and equation as model 1. However, model 5 excludes oil and energy companies in its sample and model 6 only includes oil and energy companies in its sample. The purpose of these regressions is to evaluate the influence oil and energy companies have on the regression results.

Table 3. Regression results

Dependent variable	Return on assets			Return on equity	Return on assets	
Variables	Model 1***:	Model 2***:	Model 3***:	Model 4*:	Model 5***:	Model 6***:
Constant	-71.0908*** (10.25234)	-37.098*** (6.6411)	-71.106*** (10.2320)	-1.053* (0.5447)	-65.44*** (11.089)	-73.9138** (30.7747)
Oil price	0.0285*** (0.0107)	0.0205** (0.0106)	0.0282*** (0.0107)	0.0014** (0.0006)	0.0140 (0.1105)	0.11284** (1.5481)
Ln market capitali-zation	3.4979*** (0.4719)	1.8593*** (0.3092)	3.4938*** (0.4645)	0.0501** (0.0249)	3.2476*** (0.5066)	3.994** (1.5481)
Ln leverage	-0.75978*** (0.3595)	-0.70014** (0.3144)	-0.75434** (0.35933)	0.00146 (0.0206)	-0.4481 (0.3579)	-4.5188* (1.7168)
Percentage of foreign sales	0.00757 (0.0207)	0.01576 (0.0185)		-0.00044 (0.0011)	-0.0008 (0.0215)	0.0393 (0.065)
Internatio-nalization			0.79441 (1.0110)			
R-squared:	0.0283	0.0304	0.0284	0.0838	0.0230	0.0431
R-squared within	0.1029	0.0986	0.1036	0.0160	0.0838	0.3226
R-squared between	0.0422	0.0419	0.0423	0.2959	0.0399	0.0864
Number of observations:	680	680	680	599	613	67
P-value:	0.000	0.000	0.000	0.0778	0.000	0.0018
Significance levels: *=90%, **=95%, ***=99%.						

Source: own elaborations.

4. Results

4.1. Model 1: fixed effects model

The regression results in Table 3 show that the p-value for the F-statistic is 0.000. Therefore, it can be said with more than the 99% confidence level that the model has explanatory power. However, the model can only explain 2.83% of the change in return on assets.

The data on the individual estimators for return on assets reveal that the effect of oil price on ROA is significant at the 99% level. There seems to be a positive relation between the variables where a 1 dollar increase in oil price increases ROA by 0.0285 percentage points, ceteris paribus.

The control variables for firm size (the natural logarithm of market capitalization) and leverage are significant at the 99% and 95% level, respectively. When the natural logarithm of market capitalization increases by 1%, the ROA increases by 0.0349 percentage points, ceteris paribus. The natural logarithm of leverage has a negative relation to ROA. When the natural logarithm of leverage increases by 1%, the ROA decreases by 0.0075978 percentage points, ceteris paribus.

The control variable measuring the degree of internationalization has shown to be insignificant.

4.2 Model 2: random effects model

The regression results of the random effects model show that the p-value for the chi-squared test statistic is 0.000. Therefore, it can be said with more than the 99% confidence level that the model has explanatory power. However, the model can only explain 3.04% of the change in return on assets.

The data on the individual estimators for return on assets reveal that the effect of oil price on ROA is significant at the 90% level.

The control variables for firm size and leverage have shown to be significant at the 99% and 95% level, respectively. When the natural logarithm of market capitalization increases by 1, the ROA increases by 0.0186 percentage points, ceteris paribus. The natural logarithm of leverage has a negative relation to ROA. When the

natural logarithm of leverage increases by 1, the ROA decreases by 0.0070 percentage points, ceteris paribus.

The control variable measuring the degree of internationalization has shown to be insignificant (again).

4.3. Hausman test

Models 1 and 2 indicate similar results. To test whether the fixed or random effects model is better, a Hausman test was performed.

The datapoints used are likely to be affected by individual (firm) characteristics. Therefore, the fixed effects model is expected to be the most appropriate regression model.

The results of the Hausman test confirm this hypothesis. The results show that with the 99% confidence level, the fixed effects model is more appropriate for this sample compared to the random effects model.

4.4. Model 3: fixed effects model, including dummy variable

Model 1 and 2 results show that internationalization (measured in foreign sales divided by total sales) has no significant impact on return on assets.

To confirm the finding that internationalization indeed has no statistically significant effect on the return of Dutch companies, regression model 3 was performed. It includes the percent of foreign sales variable as a dummy. The regression shows comparable results to that of model 1. In both models, the internationalization variable is insignificant. The addition of a dummy variable has not changed the significance of the internationalization variable.

4.5. Model 4: return on equity

The regression results on model 4 show that the p-value for the F-statistic is 0.0778. The model can explain 8.38% of the variation in return on equity at the 90% significance level. This coefficient of determination is notably higher than the coefficients of determination of the models measuring the variation of return on assets.

The data on the individual estimators for return on equity reveal that the effect of oil price on ROE is significant at the 95% level. There appears to be a positive relation

between the variables where a 1 dollar increase in oil price increases ROE by 0.13571 percentage points, ceteris paribus.

The control variable for firm size is significant at the 95% level, while the other control variables are not significant. When the natural logarithm of market capitalization increases by 1%, the ROA increases by 0.00050055 percentage points, ceteris paribus.

4.6. Model 5: fixed effects model excluding oil and energy companies

The sample of model 5 excludes oil and energy companies. Therefore, model 5 can help to evaluate the relationship between the oil price and the profitability of non-oil and non-energy companies.

The findings show that the model is significant at the 99% level. Nevertheless, the oil price is found to be insignificant. This indicates that for non-oil and non-energy companies there is no relationship between the oil price and profitability.

There appears to be a highly significant and positive relation between the natural logarithm of market capitalization and return on assets. When the natural logarithm of market capitalization increases by 1% return on assets increases by 0.0324763 percentage points, ceteris paribus.

The control variables leverage, and percent of foreign sales are insignificant for this model.

The r-squared value of this model is 0.0230. This is the lowest coefficient of determination of all the tested models.

4.7. Model 6: fixed effects model, only oil and energy companies

Model 6 is a fixed effects model used on a sample only including oil and energy companies. The regression results show that the model is significant at the 99% level. Additionally, the model can explain 4.31% of the variation in the return on assets of the companies in the sample.

The coefficients of the individual estimators for return on assets reveal that the oil price variable is significant at the 90% level. A 1 dollar increase in the oil price increases the return on assets by 0.1128384 percentage points, ceteris paribus.

The control variables for market capitalization and leverage are significant at the 90% level and indicate that a 1% increase in the natural logarithm of market capitalization causes the return on assets to increase by 0.03994251 percentage points, ceteris paribus. A 1% increase in the natural logarithm of leverage causes the dependent variable to decrease by 0.04518809 percentage points ceteris paribus.

5. Discussion

The findings show that the oil price has a positive effect on the profitability of Dutch public companies. However, the findings also show that this relationship is based upon the presence of oil and energy related companies in the sample.

The finding establishing the positive and significant effect of the global oil price on the profitability of oil and energy related companies confirms previous studies such as the ones by Dayanandan & Donker (2011) and Wattanatorn & Kanchanapoom (2012). Both papers acknowledge the positive relationship the oil price has on the profitability of oil and energy related companies.

Existing literature evaluating the relationship between global oil prices and the profitability of companies, provides divergent results regarding the nature of the effect of oil prices on profitability. The literature is known to be focused on single countries in its analysis. This is causing the presence of country dependent factors such as the type of companies in the country, the countries' dependence on oil, the number of oil related companies in the sample, etcetera, to determine the nature of the relationship between global oil prices and profitability.

The findings have shown that the presence of oil and energy related companies in the sample cause the overall relationship between oil prices and the profitability to be positive. The strong presence of oil and energy related companies in the sample helps to explain this finding. From the 143 currently operating public companies in The Netherlands, 12 operate directly in the oil and/or energy sector. Historically, The Netherlands always had a strong energy sector including names such as Royal Dutch Shell (till 2022). Additionally, it should be considered that the Netherlands was a major exporter of natural gas during the sample period. The well-established co-

movement of the oil and gas price could have caused the Dutch economy to indirectly profit from higher oil prices.

The findings have also shown a positive and highly significant effect of company size on profitability. This effect is a long-established phenomenon. Bigger companies can benefit from economies of scale, have more buying power and are known to operate in industries with high barriers to entry. Additionally, bigger companies have more and better access to (scarce) resources.

The control variable for leverage was significant in four of the six models. In the models where leverage was significant, leverage negatively influenced return on assets. The negative effects of leverage on profitability contradicts the general view on the risk-return relationship. Many studies have supported the Capital Asset Pricing Model, which establishes a positive relationship between risk (leverage) and return (profitability).

Lastly, the results have indicated that the degree of internationalization measured by foreign sales as a percentage of total sales has no significant impact on profitability. The benefits and drawbacks of internationalization may have similar strengths. The downsides of internationalization include cultural differences, political risk, exchange rate risks, etcetera. The benefits of internationalization include economies of scale and scope, access to new resources, diversification etcetera. The finding regarding the internationalization variable is similar to that of other papers. The literature suggests that there is a relationship between internationalization and return on assets. However, this relationship is not linear. Riahi-Belkaoui (1998) found that when the level of internationalization increases, there is a fluctuation in the rate of return on assets, initially decreasing, then increasing, and eventually experiencing a slight decrease. Since the regressions models used are based upon linear relationships, it seems logical that the internationalization variable is not significant in the tested models.

6. Conclusion

Five fixed effects regressions and one random effect regression have been performed. The Hausman test has confirmed that the fixed effects regressions are more representative for this sample data. Therefore, models 1, 2, 3, 5 and 6 are the most relevant models for answering the research question.

All models on the whole sample (model 1, 2, 3 & 4) confirm that there is a significant and positive relationship between the oil price and profitability. Models 1, 2 and 3 show a positive relationship between the oil price and return on assets, while model 4 illustrates a positive relationship between the oil price and return on equity.

Models 5 & 6 have shown that the relation between oil prices and profitability is dependent upon the presence of oil and energy related companies in the sample. Model 5 did not include oil and energy related companies in the sample, this resulted in an insignificant relationship between the oil price and return on assets. Contrary, Model 6 only included oil and energy related companies. The regression coefficients of model 6 showed a significant and strong relationship between the global oil price and profitability.

The control variable size (measured as the natural logarithm of market capitalization) is significant for all models. The control variable leverage is insignificant for the model measuring the effects on return on equity (model 4) and the model excluding oil and energy related companies (model 5).

The control variable measuring the degree of internationalization (percent of foreign sales with respect to total sales) is insignificant in all models. If the degree of internationalization is transformed to a dummy variable, it remains insignificant.

The coefficients of determination indicate that model 6 can best explain the variation on return on assets within firms. The model accounts for 32.26% of the variation within firms. Model 6 is also the best in explaining the variation of return on assets between firms. The model accounts for 8.64% of the variation in return on assets between firms.

Since all models on the whole sample are significant and show that the oil price has a significant and positive impact on profitability, the null hypothesis can be rejected:

~~*H0: There is no relationship between oil price and profitability.*~~

Additionally, hypothesis 1 can be accepted. Model 6 has shown that the oil price has much influence on the profitability of Dutch public companies operating in the oil and energy sector.

H1: There is a relationship between oil prices and profitability for companies in the oil & energy sector.

Lastly, hypothesis 2 can only be accepted partly. Model 1, 2, 3 & 4 have shown that the oil price positively affects the profitability of Dutch companies. However, model 5 & 6 suggest that this relationship is mostly based upon the presence of oil and energy related companies in the sample.

H2: There is a relationship between oil prices and profitability.

7. Limitations and recommendations

7.1. Limitations

Honoring pioneer work by André Dorsman, this study handles an interesting but limited topic: the relationship between global oil prices and the profitability of Dutch public companies.

This study has shown that the oil price has a positive impact on Dutch oil and energy related companies. Our conceptual model can explain 4.31% of the variation in return on assets of oil and energy related companies in the Netherlands. The model covers 8.38% of the variation in return on equity of all Dutch public companies.

The research is done in a straightforward way, with little support from the literature, but with an interesting tweak when non-energy companies are left out. Although the findings of the study are mostly similar to the existing literature, the study can still suffer from biases and imperfections. The study is prone to a couple biases. Firstly, no time lags are used. This can result in reverse causality. However,

this bias is limited, since the oil price is more likely to affect profitability than vice versa.

Additionally, the study can suffer from third variable bias. Variables such as the gas price and the exchange rate can have an influence on the outcome of the results. Although the control variables in this study are selected upon the precedent set by several papers, it is possible that more control variables influence the relationship between the oil price and profitability.

Finally, it should be noted that some variables did not follow a normal distribution. To make the variables more normally distributed, natural logarithms were used to transform the variables leverage and market capitalization. Yet, for the independent variables return on assets and return on equity, natural logarithms could not be used to decrease the skewness and kurtosis. The independent variables are dual-signed (negative and positive), and natural logarithms cannot be taken from negative numbers.

7.2. Suggestions for further research

The literature review has indicated that there have been several studies on the effects of the oil price on profitability and the economy. However, these studies lack generalizability. Country and company dependent factors may moderate the relationship between the oil price and the profitability of companies. The results of this study have shown that the presence of oil and energy related companies in the sample change the relationship between the oil price and profitability. Having a better understanding of which factors change the relationship between the oil price and profitability will help company managers to improve their forecasts and make more informed decisions.

Furthermore, the results of the study have shown that leverage negatively influences return on assets. This violates the Capital Assets Pricing Model (CAPM). The model suggests that more risk should be rewarded by more return. Further research could investigate the surprising results that in this study, risk (measured by leverage) was not rewarded by return (measured by return on assets and return on equity).

7.3. Managerial implications

The results of this study provide key points that managers can use to their benefit:

1. Managers of oil and energy related companies should closely analyse the fluctuations in the oil prices. The managers should develop strategies that capitalize on favourable oil prices to maximize their company's profitability.
2. Managers of non-oil and non-energy related companies should not be excessively concerned about fluctuations in the oil price. The focus of these managers should primarily be on their company's industry-specific factors.
3. Managers should carefully manage the capital structure. Excessive leverage can negatively impact the return on assets.
4. Managers should recognize the impact of company size on profitability. Larger companies have certain advantages such as greater access to resources and economies of scale.
5. Managers should carefully examine the potential benefits and risks related to internationalization. While this can offer strategic advantages, there is no guarantee for increased profitability.

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The concept of a Digital Gap Benchmarking Model for SMEs as a tool for optimizing digitalization processes

Marian GORYNIA
Poznań University of Economics, Poland
Joanna KUCZEWSKA
WSB Merito University in Poznań, Poland

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Aim: This study investigates the digital gap in enterprises (particularly SMEs) and introduces the Digital Gap Benchmarking Model as a solution to bridge this gap and enhance their digital transformation processes.

Design / Research methods: The research employs a narrative literature review of studies on enterprise competitiveness within digitalization contexts with predefined inclusion criteria. In addition, based on the concept of the digital gap for SMEs, the authors proposed original concept of a Digital Gap Benchmarking Model as a tool for optimizing the digitalization process in SMEs.

Conclusions/findings: The study identifies the digital gap along three key dimensions: digital potential, digitalization strategy, and position in the digitalization process. Additionally, benchmarking was identified as a key tool to assess and monitor digital transformation progress, helping SMEs close the digital gap and enabling to pinpoint weaknesses and strategically enhance their digital maturity.

Originality/value of the article: While many studies have examined the importance and impact of digital transformation, few have focused on how to assess and bridge the digital gap. This study addresses this gap by identifying the digital gap and proposing the Digital Gap Benchmarking Model as a tool to support SMEs in closing this gap.

Contact details: MARIAN GORYNIA, Poznań University of Economics and Business, al. Niepodległości 10 | 61-875 Poznań, Marian.Gorynia@ue.poznan.pl.; JOANNA KUCZEWSKA, WSB Merito University in Poznan,, ul. Powstańców Wielkopolskich 5, 61-895, Poznań, joanna.kuczewska@poznan.merito.pl

Keywords: digital gap, benchmarking, Digital Gap Benchmarking Model, Small and Medium Sized Companies

JEL: L20, L21, M15, M21

1. Introduction

Digitalization has become a critical driver of competitiveness and sustainable growth for Small and Medium-sized Enterprises (SMEs). In today's rapidly evolving business landscape - accelerated by technological advancements and the transformative impact of the COVID-19 pandemic - SMEs are increasingly leveraging digital technologies to enhance operational efficiency, innovate business models, and gain competitive advantages. The reorganization of global supply chains, shifts in sourcing strategies, the implementation of remote work, and the expansion of e-commerce services are among the main post-pandemic changes, highlighting the onset of digital transformation in companies (Gorynia, Kuczewska 2023). This transformation extends far beyond the mere adoption of digital technologies, although they play a crucial role in the process (Dethine et al. 2020; Saarikko et.al 2020; Vial 2019). It necessitates fundamental changes in how business processes are perceived and managed, making a digitalization strategy an essential component of a company's overall growth strategy. As digitalization reshapes industries, SMEs need to assess their digital maturity and identify areas for improvement.

Numerous researchers and organizations monitor trends in the development of modern digital technologies that are particularly significant for SMEs. The European Commission (2020, 2021, 2023) has identified three advanced technologies as crucial for Europe's future: the Internet of Things (IoT), Blockchain, and the next-generation Internet. According to the McKinsey report (2023), leading trends include artificial intelligence (AI), cloud technologies, advanced connectivity (5G/6G), blockchain, and immersive reality technologies (VR). Deloitte (2023) similarly identifies trends related to AI, cloud computing, decentralization, and blockchain. Moreover, Wynn and Jones (2022) categorized key technologies using two acronyms: SMAC – Social media, Mobile, Analytics/Big Data, Cloud and BRAID – Blockchain, Robotics,

Automation of knowledge work/artificial intelligence, Internet of Things, and Digital fabrication.

Following Alcácer and Cruz-Machado (2019), digital technologies at the core of the Fourth Industrial Revolution (Industry 4.0) are driving significant organizational changes in companies. These technologies enable firms to gain additional competitive advantages (Gorynia 2009; Kuczewska 2020). Enhanced and rapid communication (Felici et al. 2020) fosters greater collaboration between companies (Stallkamp, Schotter 2021; Dutta et al. 2020), strengthens relationships between businesses and their customers, and ultimately accelerates the internationalization process (Hanell et al. 2020). Moreover, advancements in Big Data analytics (Günther et.al 2017; Hilbert 2016), business intelligence techniques, artificial intelligence (AI) (Nishant et al. 2020) machine learning (ML), automation and robotization, the Internet of Things (IoT) (Radoglou Grammatikis et al. 2019), and blockchain (Rotundu 2022; Albekov et al. 2017) contribute to improving business processes, operations, product design, and manufacturing services (Haddud, Khare 2020; Feliciano-Cestero et al. 2023; Lecerf, Omrani 2020; Liu et al. 2020).

Numerous case studies on digital transformation in SMEs illustrate how these enterprises leverage digital technologies to enhance competitiveness, improve customer experience, achieve sustainable growth, and optimize marketing, sales, and product development processes. Over time, digital technologies have significantly reconfigured their business models, enabling SMEs to evolve from small-scale operations into major market players (Gorynia et al. 2024b; Kuczewska et al. 2023a; Kuczewska et al. 2023b). Nevertheless, while most existing studies have highlighted the importance, scope, and tools of digital transformation, its impact on business operations and constituted a solid theoretical basis from which the concept of the digital gap can be derived (Vial 2019; Wasterman et.al 2014; Matt et.al 2015, 2016; Hess et.al 2020; Kane et.al. 2015, 2017; Bharadwaj et.al 2013; Sebastian et.al. 2017), the issue of how to describe the progress and scope of digital transformation - specifically how to identify and bridge the digital gap - has not been explored in as much depth.

Notably, benchmarking has emerged as a powerful tool in this context, supporting the evaluation and enhancement of operational business processes. By systematically

identifying, learning from, and implementing best practices, benchmarking facilitates continuous improvement and strategic realignment. Previous research has demonstrated that benchmarking not only drives performance optimization but also serves as a catalyst for adapting to dynamic market conditions (Ahmed, Rafiq 1998; Kyrö 2003; Anand, Kodali 2008; Meybodi 2015).

To address this gap, the research aim of this study is to develop the digital gap concept and propose support for enterprises (particularly SMEs) in bridging this gap through the implementation of the Digital Gap Benchmarking Model. Thus, this study attempts to answer the following research questions:

Q1: How can the digital transformation process in SMEs be assessed and how can the digital gap be defined?

Q2: How can SMEs be effectively supported in bridging the digital gap and optimizing digital transformation processes?

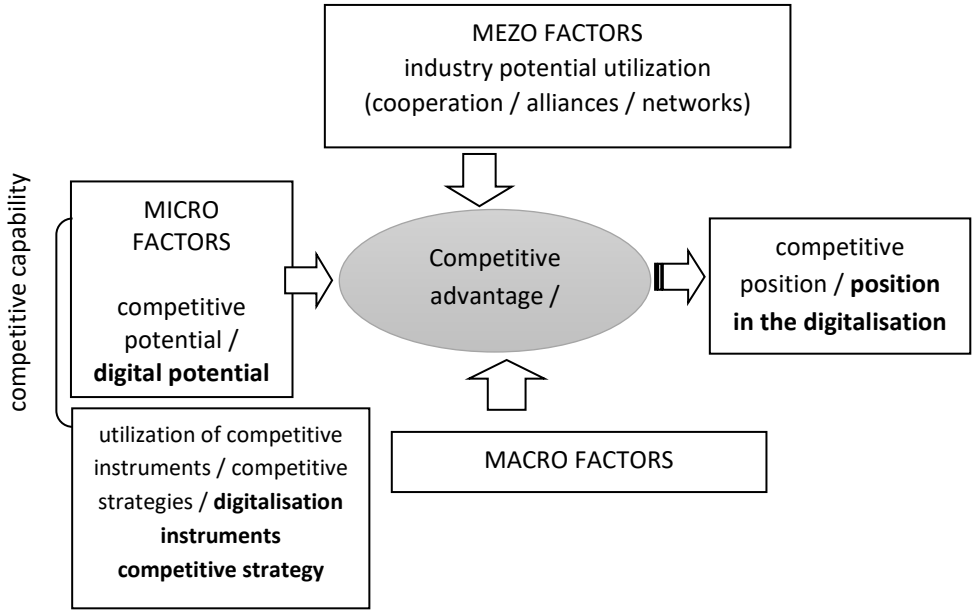
By integrating insights from the literature with empirical evidence, this study endeavours to provide a comprehensive conceptual framework that not only identifies the digital gap along key dimensions: digital potential, digitalization strategy, and position in the digital transformation process, but also demonstrates how benchmarking can support the adoption of best practices to enhance digital maturity and competitiveness.

2. Research methodology – the concept of the digital gap

The presented concept of the digital gap stems from the application of enterprise competitiveness and strategic management concepts, specifically in the context of enterprise digitalization. The starting point of this analysis is the broader concept of a company's competitive strategy, which integrates all aspects of its operations. Adopting this comprehensive perspective on the digital gap helps avoid a common mistake in strategic management – analyzing individual components of a company's activities in isolation. It is essential to recognize that digitalization is not an end in itself, nor the primary goal of a company. Rather, it is a crucial tool for achieving the fundamental objective, which is ensuring the company's survival and long-term prosperity, which is only possible through sustained competitiveness.

Furthermore, it is essential to precisely define the concepts of competitive potential and competitive position. Competitive potential can be understood in both a narrow and a broad sense. In the narrow sense, it encompasses all resources currently utilized or potentially available to an enterprise. In a broader sense, it includes additional elements such as corporate culture, resources, organizational structure, strategic vision, and the enterprise's inherent decision-making approach (strategy formulation process). Competitive position, on the other hand, should be understood as the outcome of the competitive process. It results from the application of a specific competitive strategy (a set of competitive instruments) to a given competitive potential (a set of resources). The most fundamental and concise indicators of an enterprise's competitive position are its market share and financial standing (Fałkowski et al. 2023).

Scheme 1. The concept of enterprise competitiveness versus the concept of the digital gap



Source: Authors' elaboration (Gorynia 2002; Fałkowski et al. 2023; Kuczewska 2020; Gorynia et al. 2024a).

To define and operationalize the concept of the digital gap (Fałkowski et al. 2023; Gorynia et al. 2024a), the concept of the competitive gap was utilized and analogously renamed the digital gap. This allowed for the identification of three dimensions of the digital gap: digital potential (equivalent to competitive potential), position in the digitalization process (equivalent to competitive position), and instruments of digitalization (equivalent to competitive instruments). These dimensions collectively form the digitalization strategy, which refers to the use of digital technologies in SMEs (Scheme 1).

The position in the digitalization process is, in other words, the competitive position of a company within the digital realm, viewed through the lens of the differences (advantages/strengths and gaps/deficits/weaknesses) that emerged as a result of the competitive process in the past. The digital position, as understood in this way, can be described by the following variables:

- the relative profitability (i.e., compared to industry competitors) of digitalization efforts (the ratio of results achieved to the digitization expenditure incurred),
- the scale of digitalization expenditure relative to that of key competitors,
- the level of digitalization costs (relative to major competitors),
- the characteristics of the digital technologies used compared to those of competitors,
- the awareness of the company's digitalization achievements in the market and the associated perception of the company by stakeholders.

Digital potential encompasses a range of factors related to the resources available to a company in the process of digitalization of its operations, while also including a broader set of variables. In this broader sense, a company's digitalization potential consists of the following elements:

- the resources utilized in the digitalization process,
- the company's culture concerning digitalization,
- the integration of digitalization into the company's organizational structure,
- the role of digitalization in the company's strategic vision,
- the company's digitalization behavior (strategy development process).

A company's digitalization strategy arises from the digitalization strategy formulation process. It consists of two sub-processes: the formulation of a strategic vision for digitalization and the implementation of that vision. External and internal factors influence a company's behavior, guiding it either toward a planned course (successful execution of a clear strategic vision for digitalization) or a strategic drift (resulting from either the absence of a clear strategic vision for digitalization or the inability to implement it). The conclusion drawn from these observations is that a company's digitalization strategy can also be considered a type of resource, functioning as an element of the competitive potential of digitalization.

Considering the factors influencing the size of a company's digital potential, both from internal resources and the competitive environment, it is possible to identify the digital gap of SMEs. The scale and dimensions of the digital gap, as well as a company's ability to "bridge" it, determine the long-term, sustainable, and hard-to-replicate digital position of SMEs (Scheme 2).

Scheme 2. Identification of the digital gap in SMEs

Source: Authors' elaboration (Fałkowski et.al 2023).

3. Results: the concept of a Digital Gap Benchmarking Model

Benchmarking is an ongoing process of identifying best practices, learning from them, and applying those practices to achieve optimal performance and sustainable competitive advantage (Kuczewska 2006, 2007). It is a dynamic process of comparing selected areas – or even the overall strategy – of an organization with the best practices achieved by other organizations in the same or completely different sectors (Kuczewska, Morawska 2016). Benchmarking catalyzes change; it is an ongoing, systematic search for and implementation of best practices that lead to optimal performance (Weeks 2019). Moreover, it is a dynamic method that enables continuous improvement in the organization and efficiency of a company's many processes without having to wait for the evaluation of the results achieved (Ahmed, Rafiq 1998; Codling 1998; Kyrö 2003; Anand, Kodali 2008; Meybodi 2015).

Benchmarking can be fundamentally gap into internal and external benchmarking based on the scope and extent of its implementation. Internal benchmarking is confined to a particular company or its networked subsidiaries. In contrast, external benchmarking goes beyond examining an enterprise's organizational structure, allowing the selection of a partner or best practice without restrictions regarding industry, location, or enterprise size (Kuczewska 2007; Codling 1998; Kyrö 2004; Bogan English 2004; Potoczek 2021; Saul et al. 2004 among others). Furthermore, benchmarking can be successfully applied at different levels of competitiveness, facilitating the diagnosis and implementation of best practices that contribute to building competitive advantages. In the context of internal resources and competencies, process benchmarking is most commonly employed; in competitive and location-based environments, competitive benchmarking is applied; and in the macro environment, strategic benchmarking is used (Kuczewska 2020). An analogous benchmarking methodology has been proposed by the European Commission for all three levels of competitiveness research (European Commission 1996): company benchmarking, sectoral benchmarking, and framework conditions benchmarking. This methodology enables the authors of this study to develop a concept of a Digital Gap Benchmarking Model based on a decomposed definition of enterprise competitiveness. Moreover, the contemporary concept of the Fourth Industrial

Revolution (4IR), as presented in The Global Competitiveness Report, emphasizes that competitiveness is not a zero-sum game. Consequently, cross-country comparisons, benchmarking tests, and the search for best practices are well justified (The Global Competitiveness Report 2018). Recent studies indicate the emergence of new benchmarking approaches, such as: competency benchmarking (Maciel, Wallendorf, 2017; Zhang, 2020; Brazinskas et al., 2021), intellectual capital benchmarking (Marti 2000) and network benchmarking (De Toni & Meneghetti 2000; Zagkas, Lyridis 2011; Tsironis, Matthopoulos 2015). Furthermore, the impact of digital technologies on organizational processes, as examined through benchmarking, has been explored in recent years by (Lokuge et al. 2019; Gurbaxani, Dunkle 2019; Härting et al. 2019).

Benchmarking is widely employed by organizations, institutions, and companies worldwide as a tool to support the pursuit of competitive advantages and best practices for optimizing business processes. Self-assessment models based on the EFQM Business Excellence Model – designed to enhance business processes and operations – have been implemented through initiatives such as PROBE (PROmoting Business Excellence) (Kuczewska 2007; PROBE 2025) and Benchmark index (formerly the UK National Benchmarking Index) (Benchmark Index 2025; Pilcher 2000). The Big Four global consulting firms also promote various benchmarking centers. Deloitte's Global Benchmarking Center (GBC) assists clients in assessing their performance relative to their peers and quantifying opportunities for improvement (Deloitte 2015). Ernst & Young's benchmarking analysis provides insights into companies' performance by comparing financial and related data from similar organizations (Ernst & Young 2024). PwC Saratoga's workforce and HR benchmarks offer industry-specific comparisons of turnover, hiring, career progression, productivity, and other parameters (PwC 2024). Lastly, KPMG's benchmarking compares selected financial, market, and operational parameters of a company with those of its competitors (KPMG 2024).

Concepts and models for assessing digital maturity and evaluating the sophistication of a company's digital transformation process have also emerged in the literature. The Maturity Model of Digital Transformation (Ifenthaler, Egloffstein 2019) is designed as a hierarchical model, implemented in educations organizations,

comprising six dimensions: infrastructure, strategy and leadership, organization, employees, culture, and educational technology. The Strategic Enabling Factors Model for Digital Maturity (Salviotti et al. 2019) posits that developing a specific set of digital capabilities leads to higher digital maturity, and organizations with greater digital maturity achieve superior corporate performance. Digital maturity refers to the extent to which organizations systematically prepare themselves to adapt to ongoing digital change. In this model, ten aspects of the value chain framework are used to measure digital maturity. The Sticky Digital Maturity Model 4.0 (Gill, VanBoskirk 2016) was developed to help organizations assess their digital readiness. Its assessment questions address the core capabilities, attitudes, and competencies that characterize a mature digital operation, focusing on three key dimensions: overall digital transformation, digital marketing, and digital business. Additionally, the Open DMAT targets any company seeking a comprehensive self-assessment. The Open DMAT (Digital Maturity Assessment Tool), used by EDIHs, provides results for an individual company without comparison to others (EDIH 2024).

Following a review of the literature (Chang et al. 2011; Gill, VanBoskirk 2016; Salviotti et al. 2019; Ifenthaler, Egloffstein 2019) and drawing on the authors' own expertise, it is possible to identify several critical factors affecting the assessment of the digital gap in SMEs. Consequently, the authors propose a concept of the Digital Gap Benchmarking Model for SMEs. Maturity models can either be descriptive (as-is assessment), prescriptive (to-be assessment) or comparative (benchmarking) (Röglinger et.al 2012). This model is based on a fundamental categorization of digital potential and digitalisation strategy, as well as on the position in the digitalisation process, which is evaluated using input (effort) and output (performance/impact) criteria (EFQM 2025, Uygur, Sümerli 2013; Benchmark Index 2025, PROBE 2025).

This framework enables the assessment of a company's performance and facilitates comparisons with other entities. Thus, our model is a comparative benchmarking model.

Scheme 3. The concept of a Digital Gap Benchmarking Model for SME

<table>
<tr><th colspan="3">DIGITAL POTENTIAL AND DIGITALISATION STRATEGY</th><th colspan="2">POSITION IN THE DIGITALISATION PROCESS</th></tr>
<tr><td>Development of a digitalisation strategy</td><td>The role of digitalisation in the company's strategic vision</td><td>Digital processes</td><td rowspan="2">Profitability compared to industry competitors</td><td rowspan="2">Expenditure on digitalisation</td></tr>
<tr><td>Digital culture</td><td>Digital competencies of employees</td><td>The company's digital resources</td></tr>
<tr><td>Digital organisational structure</td><td colspan="2">Cybersecurity</td><td rowspan="2">Uniqueness of digital technologies used compared to competitors</td><td rowspan="2">Digital success in relation to market trends</td></tr>
<tr><td colspan="2">Collaboration/alliances/ networks</td><td>Organization of supply chains in acquiring digital technologies</td></tr>
<tr><td colspan="3"></td><td>Acceptance and implementation of the digital strategy by employees</td><td>New business models</td></tr>
<tr><td colspan="3">EFFORT</td><td colspan="2">IMPACT / PERFORMANCE</td></tr>
</table>

Source: Authors' elaboration.

Both parts of the model - Digital Potential and Digital Strategy, as well as Digital Position - were defined and operationalized based on the authors' original concept of digital gap (Fałkowski et al. 2023; Gorynia et al. 2024a), the digital maturity research and models presented in the relevant literature (Vial 2019; Salviotti et al. 2019; Wasterman et.al 2014; Uygur, Sümerli 2013; Matt et.al 2015, 2016; Hess et.al 2020; Kane et.al. 2015, 2017; Yilmaz 2021; Rossmann 2018; Bharadwaj et.al 2013; Sebastian et.al. 2017) as well as benchmarking and self-assessment models (Uygur, Sümerli 2013; EFQM 2025; Suárez et.al 2013).

Digital potential and digital strategy

1. The role of digitalisation in the company's strategic vision - top management shared digital vision (Salviotti et al. 2019).
2. Development of digitalisation strategy (top management transformative vision) (Salviotti et al. 2019) - the proper process of developing a digitalisation strategy – support from senior directors, innovative spirit of managers, IT knowledge of managers
3. Digital culture and its acceptance by employees – user participation.
4. Digital organisational structure – the integration of digitalisation into the organisational structure of the company – experience on the information system, strength of information
5. Digital processes – compatibility of digital technologies

6. The company's digital resources – available digital technologies, complexity of IT technologies, advantage of digital technologies
7. Position in the value chain regarding the use of digital technologies
8. Digital competencies of employees – experts in internal technical support, employees expertise knowledge and IT skills
9. Organisation of supply chains in acquiring digital technologies – dependence on digital technology suppliers, support of suppliers
10. Cybersecurity and data protection.
11. Collaboration/alliances/networks with partners/competitors in the implementation of digital technologies – support and efficiency of consultants, competitive pressure, pressure from cooperative partners, customer support.

Digital position

1. Profitability compared to industry competitors – expenditure on the implementation of digital technologies.
2. Expenditure on digitalisation – investment cost vs. profit.
3. Uniqueness of digital technologies used compared to competitors – does the company possess leading technologies, and how compatible are the digital systems?
4. Digital success in relation to market trends.
5. Acceptance and implementation of the digitalisation strategy by employees – engagement in change, openness to acquiring knowledge.
6. New business models – e-commerce, e-delivery, e-procurement.

This is the first stage of our research - the conceptualization of the model. It is essential that maturity model development is conducted with complete transparency and follows a clearly defined methodology. Model evaluation and validation must be thoroughly performed before any transfer or generalization of the model can be considered. In the next phase, we will extend our research to include empirical investigations among SMEs. Based on the model, the next research phase will generate a list of benchmarks on a Likert scale (1–5), enabling companies to assess both the magnitude and direction of the digital gap (i.e., whether there is a negative

or positive gap) through comparisons with other SMEs. This will allow us to validate and refine the proposed model based on real-world data, ensuring its practical relevance and effectiveness across diverse contexts.

4. Concluding remarks

The research aimed to identify the digital gap and propose support for enterprises (particularly SMEs) in bridging this gap through the implementation of the Digital Gap Benchmarking Model. Utilizing the concept of the digital gap, this study addresses the first research question: How can the digital transformation process in SMEs be assessed and how can the digital gap be defined? The presented concept of the digital gap emerges from the application of enterprise competitiveness and strategic management frameworks within the context of enterprise digitalisation. To define and operationalize this concept (Fałkowski et al. 2023), the notion of the competitive gap was repurposed and analogously renamed the digital gap. This approach allowed for the identification of three dimensions: digital potential (equivalent to competitive potential), position in the digitalisation process (equivalent to competitive position), and instruments of digitalisation (equivalent to competitive instruments).

In addition, the authors of this study demonstrated the role and justification for employing benchmarking as a tool to support the assessment of the digital gap and monitor progress in the digital transformation process, thereby addressing the second research question: How can SMEs be effectively supported in bridging the digital gap and optimizing digital transformation processes? The evidence indicates additionally that benchmarking is an effective method for identifying the digital gap and uncovering best practices to bridge it. Defined as an ongoing, systematic process of identifying, learning from, and applying best practices to achieve optimal performance and sustainable competitive advantage (Kuczewska 2006, 2007; Weeks 2019), benchmarking can be applied at various levels: process, competitive, and strategic to facilitate the diagnosis and implementation of best practices (Kuczewska 2020; European Commission 1996). Drawing on the literature (Chang et al. 2011; Gill, VanBoskirk 2016; Salviotti et al. 2019; Ifenthaler, Egloffstein 2019) and the

authors' own expertise, a Digital Gap Benchmarking Model for SMEs is proposed. This model categorizes digital potential, digitalisation strategy, and position in the digitalisation process evaluated using input (effort) and output (performance/impact) criteria to enable performance assessment and comparisons with other entities.

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Sokrates Forms – a research instrument for creating social impact of science on the example of system risk management

Johannes (Joost) PLATJE, WSB Merito University in Wrocław, Poland, Research Centre for System Risk Management

Rafał PALAK, Krystian WOJTKIEWICZ, Wrocław University of Science and Technology, Poland

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Abstract:

Aim: This paper introduces Sokrates Forms, an innovative survey instrument with advanced functionalities that enhance data accuracy, respondent engagement, and compliance with data protection regulations. The primary objective is to develop and implement a dynamic, secure, and customizable survey tool that supports both cross-sectional and longitudinal studies while offering a feedback mechanism to participants.

Design / Research methods: The study presents the architecture, methodology, and implementation of Sokrates Forms, highlighting its modular and scalable design. The tool integrates adaptive survey paths, rigorous data validation protocols, and a personalized feedback system, which not only improves response quality but also fosters user engagement. Anonymization features ensure compliance with data protection standards, allowing surveys to be conducted either anonymously or through login-based participation for repeated studies. A case study on assessing organizational vulnerabilities in the context of system risk management demonstrates the tool's application in real-world research scenarios.

Keywords: data collection, social impact of science, system risk, Pareto Principle, functional stupidity, black swans

JEL: C81, D63, D81, D84

Contact details: Rafał PALAK, Wrocław University of Science and Technology, Wybrzeże Wyspiańskiego 27, 50-370 Wrocław, Poland. E-mail: rafal.palak@pwr.edu.pl.

1. Introduction

When conducting surveys, the respondent, in general, does not receive direct feedback. Direct feedback is rather a feature of, for example, existing instruments on political preferences or psychometric characteristics, widely used in psychological practice (e.g., Allen 2022). However, the social researcher does not have cheap access to a survey instrument with a feedback function creating, for example, a risk profile for the user. When using applications for examinations, like in Moodle, Google docs or MS Forms, the respondent can receive feedback on individual questions. But this is rather unavailable for every individual answer, with for example multiple choice questions. Therefore, the authors decided to create Sokrates Forms, in the framework of the Research Centre for System Risk Management, aimed at collecting surveys and provided the respondent with aggregated feedback as well as feedback to individual questions.

These functions, besides being useful for the user in educational settings, of in business consulting, can also be advantageous for collecting surveys. The promised feedback provides a benefit for the respondent, which may increase the willingness to fill out the survey. Feedback may consist of text, but also links to websites, articles, films, and other materials. While the survey can be carried out with a commonly accessible link, it is also possible for the user to create an account, which remains anonymous for the administrator. This fulfills the General Data Protection Regulation (GDPR) and allows for carrying out research surveys over time. This, of course, creates methodological challenges when combined to the feedback function. But also opportunities, when, for example, the feedback function is used for a teaching intervention.

This study explores the design, methodology, and implementation of Sokrates Forms, emphasizing its modular and scalable architecture. The platform incorporates adaptive survey pathways, robust data validation mechanisms, and an interactive feedback system to enhance both response quality and participant engagement. To uphold data protection standards, Sokrates Forms includes advanced anonymization features, enabling surveys to be conducted either anonymously or through secure login-based participation for longitudinal studies. After a discussion of respondent-

level challenges and tool design, the practical application of this tool is illustrated through a case study focused on assessing organizational vulnerabilities in the context of system risk management.

2. Respondent-level challenges

While Sokrates Forms is a broadly applicable survey collection instrument, it has been specifically developed to assess users' preparedness for system risks embedded within their individual goals. Beyond this primary function, its applications extend as far as researchers and practitioners can envision, allowing for customization to suit diverse research needs.

The growing reliance on digital surveys in scientific research has highlighted the limitations of conventional survey platforms, particularly in addressing issues such as data quality, participant engagement, and methodological rigor (Groves 2006, Robbins 1999). Traditional survey tools often struggle with mitigating common biases, ensuring data integrity, and adapting to the dynamic nature of research questions (Elston 2021). In response to these challenges, Sokrates Forms introduces an innovative approach, integrating advanced functionalities to enhance the accuracy, reliability, and interactivity of survey-based research.

Lack of respondent engagement presents a significant challenge. Excessively long surveys, complex question structures, and the absence of respondent incentives contribute to survey fatigue, increasing the likelihood of superficial or incomplete responses. Ochoa (2023) points out that the most important factors influencing the decision were the reward level and the survey length. This suggests that participants place greater importance on the benefits they receive rather than on potential inconveniences, such as limited time to complete the survey or the risk of disrupting their current activity. Kunz (2024) demonstrates that a high level of burden significantly affects response quality. For example, it leads to more missing responses, a higher number of incorrect answers in knowledge questions, increased straight lining, failures in attention checks, and faster response times. They also note that, from a practical standpoint, the respondents' perception of the burden is more critical than the actual length of the survey. To address these concerns, Sokrates Forms

incorporates a dynamic feedback mechanism, which not only improves respondent motivation but also enhances the quality of the collected data.

A unique feature of Sokrates Forms is its capability to allow respondents to create an account without compromising anonymity. Through a unique identifier system, researchers can track responses over time without accessing personally identifiable information. This feature facilitates the distribution of survey questions across an extended period, making the tool particularly suitable for experimental research, longitudinal studies, and focus group analysis (Audette 2020). For instance, researchers studying student motivation over several academic years or employee knowledge retention in corporate training programs can leverage this system to ensure continuity and data integrity .

3. Tool design

This section outlines the structural and functional principles guiding the development of Sokrates Forms, emphasizing its modular design, integration of personalized analysis, data protection compliance, and user-centred adaptability.

3.1 Core design principles

The architecture of Sokrates Forms is built on fundamental principles that ensure its effectiveness, flexibility, and longevity. Modularity allows for independent development and maintenance of different components, facilitating seamless updates and feature enhancements.

Scalability is another key consideration, enabling the tool to handle diverse survey sizes and accommodate large volumes of respondents without performance degradation. This ensures that the platform remains effective for both small-scale studies and extensive research projects requiring high data throughput.

Additionally, Sokrates Forms is designed with flexibility in mind. It supports a wide array of survey types and methodologies, allowing researchers to tailor surveys to their specific requirements. This versatility makes it a valuable tool across multiple disciplines, including social sciences, psychology, disaster management, and market research.

3.2 Personalized analysis integration

To optimize data collection, Sokrates Forms integrates real-time adaptive algorithms that dynamically adjust survey paths based on respondents' inputs. This feature ensures that questions remain relevant to individual participants, reducing redundancy and increasing engagement. By tailoring the sequence of survey items, researchers can obtain more nuanced data, leading to richer and more precise analyses.

3.3 Anonymization compliance

Ensuring compliance with data protection regulations is a critical priority in the design of Sokrates Forms. The platform aligns with key frameworks such as the General Data Protection Regulation (GDPR), integrating advanced anonymization techniques to safeguard respondent privacy (Voight, von dem Bussche 2024).

Practical implementations of these compliance measures include secure data handling protocols, irreversible hashing techniques, and user-friendly consent management systems. These safeguards ensure that researchers can collect valuable longitudinal data while maintaining strict ethical and legal standards.

3.4 User-friendly and adaptable interface

Sokrates Forms prioritizes accessibility and usability across a wide range of devices, from mobile phones and tablets to desktop computers. Its responsive interface allows for intuitive navigation and customization, ensuring a seamless experience for both researchers and participants.

The tool also provides extensive customization options, enabling researchers to modify survey layouts, select diverse question types, and apply logic-based conditions to survey flows. These features enhance the adaptability of the platform, making it suitable for various research contexts and analytical needs.

3.5 Innovative feedback mechanism

A key innovation within Sokrates Forms is its dynamic feedback system. After respondents complete a survey, their answers are aggregated according to the assigned metrics, and personalized feedback is generated based on pre-defined value ranges (see Table 1 at the end of the article for an example). This process not only enhances the survey's analytical depth but also incentivizes users to engage more thoughtfully with the questions if informed about the feedback in advance. By providing tailored insights, respondents receive immediate value from their participation, setting Sokrates Forms apart from traditional survey tools.

3.6 Data validation and survey integrity

To ensure high-quality data collection, Sokrates Forms implements a comprehensive set of validation protocols that safeguard the integrity of survey responses throughout the creation and execution process.

- Unique identifiers: each survey element, including question IDs and metric names, is assigned a distinct identifier to prevent conflicts and ensure seamless data organization.
- Consistency verification: automated validation processes systematically assess data structures, cross-referencing survey components to detect discrepancies, missing fields, or format inconsistencies.
- Error prevention: by identifying and resolving data inconsistencies at the input stage, Sokrates Forms minimizes post-survey data cleaning efforts, thereby enhancing the accuracy and reliability of collected responses.

3.7 Multimedia integration and adaptive display

Recognizing the impact of visual elements on engagement and comprehension, Sokrates Forms facilitates seamless multimedia integration and dynamic question presentation.

- Embedded media support: researchers can incorporate images or videos via direct URLs, with built-in format recognition ensuring proper display. This feature enhances question clarity and enriches respondent interaction.

- Conditional logic for question flow: The platform supports logic-based display conditions that dynamically adjust question visibility based on prior responses. Researchers can implement both simple and compound conditions (AND, OR, NOT operators), enabling a tailored survey experience that improves participant engagement and data relevance.

3.8 Customizable consent management

Transparency and ethical compliance are central to Sokrates Forms, which provides researchers with the flexibility to design custom consent agreements.

- Explicit research scope disclosure: the consent interface allows survey creators to clearly outline the purpose, methodology, and data-handling procedures.
- Mandatory agreement mechanism: participants must actively acknowledge the terms before proceeding, ensuring informed consent and adherence to ethical research standards.

By integrating customizable consent options, Sokrates Forms enhances participant trust while reinforcing compliance with data protection regulations.

3.9 Mitigating bias with multiple survey versions

To minimize potential biases, Sokrates Forms enables the creation of multiple versions of a survey.

- Diverse survey configurations: researchers can design and distribute multiple variations of a survey, ensuring robust methodological control.
- Automated version assignment: the platform randomly assigns a specific version to each respondent, maintaining balance in distribution.
- Independent data aggregation: response patterns across different versions are analysed separately, allowing researchers to assess potential biases introduced by question sequencing or wording.

This functionality strengthens the validity of survey-based research by ensuring that insights are derived from a balanced and methodologically sound dataset.

3.10 Enhanced privacy and anonymization measures

Privacy protection is a foundational principle of Sokrates Forms, ensuring that respondent identities remain secure while maintaining data usability.

- Flexible anonymity options: researchers can configure surveys for either anonymous participation or login-restricted submissions, allowing for repeated measures without exposing personal identities.
- Irreversible hashing for secure tracking: in cases where participant tracking is required, responses are assigned a one-way encrypted identifier, enabling longitudinal analysis without compromising confidentiality.
- Transparent privacy communication: prior to survey participation, respondents receive clear information about data protection measures, fostering transparency and trust.

Through these advanced anonymization features, Sokrates Forms provides a secure and ethically responsible survey environment, balancing rigorous research requirements with robust privacy safeguards.

By combining these functionalities, Sokrates Forms empowers researchers to design sophisticated, high-integrity surveys that not only enhance data quality but also stimulate participant engagement and trust, ensuring compliance with the highest ethical and methodological standards.

3.11 Comparison to other tools

The assessment of the differences with other tools is the topic for future in-depth research. We present here the innovative features of Sokrates Forms that make it an attractive tool compared to current low cost tools such as Google Forms and Microsoft Forms.

Unlike the cheaper traditional platforms, where respondents receive only a standard confirmation upon submission and eventually feedback on individual questions, Sokrates Forms introduces a dynamic feedback mechanism. This means that at the end of a survey, the user can receive a personalized analysis, such as a risk profile, which not only makes the survey experience more engaging but also increases motivation to provide complete and thoughtful answers. While this function exists in

instruments for, e.g., psychometric research, Sokrates Forms makes it available at a low cost.

Like other survey tools, Sokrates Forms uses advanced real-time data validation. It offers basic checks, such as verifying email address format, and automatically detects inconsistencies or errors during data entry, eliminating the need for later corrections. This functionality improves the overall quality of the collected data and shortens the time required for analysis.

Privacy protection is another area distinguishing Sokrates Forms. While most popular tools only offer anonymous form submissions, Sokrates Forms implements advanced data protection mechanisms. By using unique identifiers and one-way hashing techniques, it enables longitudinal studies without compromising participant anonymity. This solution is particularly valuable for research requiring the tracking of changes over time while maintaining full confidentiality.

The modular architecture of Sokrates Forms allows for easy scalability and adaptation to various project types, from small academic studies to extensive longitudinal research, and provides high flexibility and quick adaptability in survey design.

4. Case Study: enhancing the social impact of science through feedback mechanisms in risk assessment

4.1 Development of the questionnaire: theoretical foundations and empirical refinement

4.1.1. Theoretical foundations: The Pareto Principle, functional stupidity and black swans

Early Warning Systems (EWS) play a crucial role in disaster management and security planning by providing timely alerts about potential hazards (Khankeh 2019). However, empirical studies suggest that despite the existence of EWS, stakeholders frequently ignore or downplay warnings, leading to inadequate risk preparedness (Taleb 2007, 2012; Wucker 2016). A key challenge in risk governance is understanding the vulnerabilities of individuals, organizations, and regions, as well as

identifying the cognitive biases and structural barriers that prevent effective response to warnings (Taleb 2012; Kahneman 2011).

To address these challenges, Sokrates Forms has been developed as an interactive web-based instrument designed to assess system risk perception and provide personalized feedback to stakeholders. By collecting and analysing the perceptions of local stakeholders, the tool enables the identification of patterns in risk awareness and response behaviour. The integration of statistical evaluation mechanisms allows for the construction of robust models that inform policy decisions and improve overall risk preparedness.

This case study demonstrates how Sokrates Forms serves as a dynamic research tool that not only facilitates stakeholder assessments but also enhances public engagement through its interactive feedback features. By offering individualized insights and tailored recommendations, the tool strengthens the social impact of scientific research, transforming risk perception studies into actionable knowledge that benefits both policymakers and at-risk communities.

The development of the questionnaire is grounded in three key theoretical frameworks: the Pareto Principle, Alvesson and Spicer's concept of Functional Stupidity, and Nassim Taleb's Black Swan theory. The Pareto Principle, or the 80/20 rule, suggests that in many systems, a small proportion of causes or inputs accounts for a disproportionately large share of effects or outcomes (See Taleb 2012). Applied to risk perception and preparedness, this principle implies that a small number of critical vulnerabilities or cognitive biases may exert an outsized influence on an organization's overall resilience.

Alvesson and Spicer's (2012) concept of Functional Stupidity highlights the tendency of individuals and organizations to avoid critical thinking, reflexivity, and uncomfortable truths, often in the pursuit of short term profit goals, efficiency, and group cohesion. This avoidance can lead to systematic negligence of early warning signs, dismissal of alternative viewpoints, and resistance to acknowledging systemic risks. As a result, organizations may create environments that foster complacency, discourage dissent, and fail to prepare for potential disruptions. The questionnaire incorporates this perspective to assess the extent to which respondents exhibit risk-

blindness, unquestioned adherence to organizational norms, and an inability to recognize or act on systemic vulnerabilities.

Incorporating Nassim Taleb's (2007) Black Swan theory further strengthens the framework by accounting for small-probability, high-impact events that often remain unanticipated due to cognitive biases and overreliance on historical patterns. Taleb argues that rare, unpredictable events with extreme consequences, so-called Black Swans, are frequently dismissed or underestimated because they fall outside conventional risk models. Organizations and individuals tend to focus on what is known and quantifiable, ignoring outlier risks that can catastrophically reshape entire systems. This oversight is often exacerbated by Functional Stupidity, where decision-makers resist acknowledging the possibility of disruptive anomalies, preferring instead to operate within familiar paradigms. Furthermore, as suggested by the Pareto Principle, even a small number of overlooked vulnerabilities can significantly amplify the impact of Black Swan events, increasing systemic fragility.

Together, these three theoretical foundations provide a multidimensional lens for understanding why stakeholders fail to recognize and respond to risks effectively. Whether due to structural inefficiencies and concentrated vulnerabilities (Pareto Principle), deliberate ignorance and intellectual inertia (Functional Stupidity), or the inherent unpredictability of extreme events (Black Swan theory), the questionnaire is designed to identify and measure these critical risk perception challenges.

4.1.2 Empirical refinement

Initially, the questionnaire was conceptualized as a broad-ranging assessment tool, consisting of approximately 100 questions aimed at evaluating risk perception and organizational vulnerability. To refine its structure and applicability, a series of empirical validation workshops and field studies were conducted between 2016 and 2018 in Germany and Poland. The first major testing phase took place in 2016 at IHK Magdeburg, where industry professionals and risk management experts assessed the practical relevance and clarity of the questionnaire. In 2018, further studies were carried out at a meeting with business representatives and among a Swiss and a German company (Platje, 2019). This process helped streamline the questionnaire, ensuring its universal applicability across sectors. Concurrently, workshops in

Wrocław (2016–2018) allowed for further refinements, focusing on question clarity, response consistency, and applicability.

In 2024, the questionnaire was integrated into Sokrates Forms. The finally selected 20 survey questions are presented in Table 1. This integration introduced real-time data validation, dynamic survey adaptation, and automated feedback generation, enhancing user engagement, and the tool's overall analytical capacity. Beyond its application in research and risk governance, the questionnaire has also been employed in executive education and academic programs, particularly in a course on Unsustainable Economics, where professionals from business, government, and academia engaged with the tool.

Table 1. Survey questions

The survey questions:
Please answer the following questions in the context of your company's operations:
1. In our organization, we do not discuss mistakes.
2. We strive to create a positive atmosphere for finding solutions to emerging problems.
3. Things that almost went wrong are discussed, and conclusions are drawn.
4. In our company, one can freely challenge/criticize management decisions/ideas.
5. Changes in rules are openly discussed in our company.
6. Company management often provides reasons and explanations for its decisions.
7. Employees of the company/organization are eager to provide feedback to other involved individuals.
8. Overall, there are too many changes in our company, with too little time to implement and manage them.
9. Our company relies on one or a few good employees.
10. Our company depends on one or a few good managers.
11. Our company ignores threats to its existence that are difficult to quantify.
12. Our company ignores unlikely threats.
13. Our company is dependent on one or a few suppliers.
14. If necessary, our company can easily find new suppliers.
15. If necessary, our company can easily find new clients.
16. Our company is dependent on one or a few clients.
17. Our company is highly innovative.
18. Our company's innovations increase dependence on highly qualified and hard-to-access employees.
19. Our company's innovations have made it more dependent on a few suppliers.
20. Our company's innovations have made its management more complicated.

Link to survey: https://system-risk-research.org/strengthen-your-company/

4.2 Personalized profiling and benchmarking

To improve risk awareness, individualized risk profiles were generated, based on user responses. Sokrates Forms assigns a score to each question, allowing to aggregate the scores, and to create feedback using benchmarking principles. An example of the simplest form of feedback is presented in Table 2. This feedback is the basis for further in-depth analysis, e.g., through meetings between an expert and the respondent(s). Future functionalities of Sokrates Forms will allow for comparative benchmark analyses, showing how the respondent's profile or perceptions aligns with that of their peers, industry standards, or regional averages. Longitudinal tracking allows users to monitor changes.

4. Conclusion

In conclusion, Sokrates Forms emerges as a highly versatile and robust platform tailored to meet a wide spectrum of survey needs. Its advanced functionalities, ranging from feedback and stringent data validation to the seamless integration of multimedia content, equip users to design and deploy surveys that are both engaging and reliable.

The platform's adaptability is evident in its application across diverse domains. In customer surveys, it enables precise market research and informed product development by offering tailored survey experiences. Its capacity for managing dynamic content and tracking participants over time should ensure the collection of consistent and ethically handled data. Furthermore, in health-related fields, Sokrates Forms may support the collection of critical patient feedback and public health data, thereby contributing to improved treatment outcomes and effective public health strategies.

Overall, Sokrates Forms not only enhances the quality of data collection but also builds trust through its rigorous privacy and validation measures. This comprehensive approach makes it an invaluable tool for both academic research and commercial applications, ensuring that every survey yields actionable insights and contributes to informed decision-making.

Table 2. Survey feedback

Aggregated feedback. The questions had a Likert item scale from 1 to 5. The more points, the less the perceived vulnerability. The total score was calculated an feedback was provided for different score intervals. The feedback was generated with help of ChatGPT 4o, in an iterative process of adapting the text. In order to integrate the proper theoretical background in the general feedback. This feedback is a basis for in-depth further discussion within the organization. **High Level of Fragility/Vulnerability: 20-46 points.** Your responses indicate that your organization may be exposed to various threats and weaknesses, such as dependence on key individuals or suppliers, lack of open communication, and ignoring potential threats. This score means that the company is at a high level of vulnerability, which could lead to significant problems in the event of unexpected events. It is recommended to conduct a thorough analysis of existing risks and take actions to mitigate them. Your company may be exposed to serious risks that could cause problems in the future. It might be worthwhile to consider steps to minimize risks and strengthen the company's resilience. Think about how to improve openness to change and strengthen communication within the organization. We recommend analyzing these areas and considering strategies that could strengthen the company. It may be useful to investigate how other companies handle similar challenges and how these practices could be applied within your organization. **Medium Level of Fragility/Vulnerability: 47-73 points.** The results indicate that your organization recognizes some potential weaknesses but does not consider them to be very serious. This balanced approach can be beneficial; however, it may be worth considering if some of these areas could become more problematic in the future. We encourage you to analyze and implement corrective measures to strengthen these weak points and prepare the company for future challenges. The score suggests the presence of solid foundations, but also areas that may need strengthening. It indicates that the company has certain areas requiring improvement in terms of risk management and sensitivity to change. It would be worthwhile to focus on those aspects that could generate risks and to explore ways to minimize them. **Low Level of Fragility/Vulnerability: 74-100 points.** Your results suggest that your organization is well-prepared for potential threats and weaknesses. This is excellent news! To maintain this advantage, it's beneficial to regularly review and update risk management strategies and continue building a culture of open communication and innovation. We encourage you to share your best practices and continue improving organizational management. The score indicates that the company has a low level of vulnerability to threats. A well-developed organizational culture, open communication, and flexibility in risk management ensure that the company is prepared for unforeseen situations. It's important to maintain these good practices and continue enhancing awareness within the organization. Your company appears to be well-prepared for various challenges. A conscious organizational culture and openness to change are key assets that are worth nurturing. Keep up the good work and consider what innovations could further increase your company's resilience.

Link to survey: https://system-risk-research.org/strengthen-your-company/

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