HOW TO GOVERN YOUR GREEN IT? - VALIDATING A CONTINGENCY THEORY BASED GOVERNANCE MODEL

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Abstract

Although practitioners have begun to implement Green IT into their companies, the governance of sustainable information systems varies significantly. Only little has been done to explain these differences in Green IT governance. Building upon contingency theory and IT governance, we develop a contingency model for Green IT governance which demonstrates the fit between contingencies and the company-specific configuration of Green IT. In the first step, three archetypes of Green IT governance reaching from centralized over federal to decentralized are presented. In the second step, we identify from literature eight contingency factors determining the ideal type of Green IT governance. The contingency model is validated by a questionnaire using factor and regression analysis. With the enhanced understanding of how Green IT governance is shaped by contingency factors, organizations are able to select the most successful Green IT governance form.

Keywords: IT Governance, Green IS, Green IT, contingency theory
1 INTRODUCTION

In information systems (IS) research, the environmental impact of information technology (IT) and related measures for its reduction and management are being discussed under the headlines of Green IS and Green IT (Watson et al. 2010, Yi and Thomas 2007). Green IS incorporates the measures and activities of an enterprise’s IT department to achieve environmental sustainability (Chen et al. 2008, Molla et al. 2009, Schmidt 2011).

During the last five years, many organizations have begun to implement sustainability aspects into their IT infrastructure and business process management (Molla et al. 2009). However, the allocation of governance types for these Green aspects has not yet been explained in research. Various researchers have made significant progress in explaining the organizational structure and IT governance of corporations (e.g., Brown 1997, 1999, Tavakolian 1989, Wetherbe and Whitehead 1977, Yajiong et al. 2008). Building upon this, we want to extend this research to the specific case of Green IT governance.

Referring to contingency theory, different researchers suggest using contingency factors such as competitive strategy, firm size, or organization structure to explain decision-right differences within IT management among organizations (Ein-Dor and Segev 1982, Olson and Chervany 1980, Tavakolian 1989). Melville (2010) also suggests the application of contingency theory to examining organizational differences in the management of sustainability.

In this paper we chose a multi-method approach for applying contingency theory to Green IT governance. The following three research questions could be answered:

- Which Green IT governance patterns exist in theory and practice?
- Which contingency factors exist for Green IT governance?
- To what extent do these factors explain the allocation of Green IT governance within organizations?

While this paper focuses on the coordination aspect of Green IT governance, it does not examine guidelines or compliance facets. We started our research with a thorough literature review on the three important domains of our proposed model: IT governance, Green IT, and contingency theory. We then constructed a model using the revealed knowledge by defining three archetypes of Green IT governance and eight contingency factors, additionally formulating eight hypotheses. To get a first approval for our model, we used the data gained from five case studies with organizations from different industries (Schmidt and Kolbe 2011). In this paper we present a survey to further validate our model. It was sent to a large number of organizations from a variety of industries and with different firm sizes. The completed questionnaires were evaluated using factor and regression analyses. For a comprehensive view on our research process, see Figure 1.
2 RELATED RESEARCH

2.1 Green information systems

Because of the vastly growing consumption of natural resources and increased greenhouse gas emissions, sustainability has been considered an essential concept within corporate management (Lubin and Esty 2010). The predominant understanding of sustainability is shaped by the Brundtland Commission’s definition as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (World Commission on Environment and Development, 1987). This definition is broad and somewhat imprecise, making it difficult for organizations to apply the concept in the business environment. Sustainability at the business level has emerged as a concept of long-term, simultaneous optimization of economic, environmental, and social objectives to generate lasting, superior financial business performance (Epstein and Roy 2001, Elkington 1997). Its three dimensions are not mutually exclusive and provide a framework according to which corporations can measure and report their performances and organizational successes.

While organizations are still motivated to adopt sustainable business practices (Seidel et al. 2011), the IS research community is encouraged to clarify the role of IS in contributing to these efforts by using its transformative potential (Watson et al. 2010, Melville 2010). This has resulted in the term Green IS, which is more extensive than ‘Green IT’ and comprises a greater variety of possible initiatives to support sustainable business processes and its management (Watson et al. 2010, Boudreau et al. 2008). We understand Green IS as ‘green by IT’ and Green IT as ‘green in IT’ (Schmidt 2011). In order to address the importance of a lifecycle approach for corporate business, Green IS research has recently taken Business Process Management into account, resulting in the term ‘Green BPM’ (Seidel and Recker 2011). All three constructs mentioned (Green IS/IT/BPM) must be governed somewhere within a corporation. As we learned from our research, in contrast to the academic community, corporations do not necessarily distinguish between the concepts and describe all Green IS/IT/BPM activity as Green IT. Therefore, within this paper we use the term ‘Green IT governance’ to refer to all governance activities concerning Green IS, Green IT, and Green BPM.
2.2 Green IT governance and contingency theory

Contingency theory is a well-known part of the behavioral research and describes the relation between the contextual factors, e.g., technology or environment, and the organizational structures. It provides a method for discussing the effects of organizational variables (Burns and Stalker 1961, Woodward 1965, Hage and Aiken 1967, Lawrence and Lorsch 1967, Thompson 1967, Perrow and Hall 1972).

The term ‘IT governance’ refers to the organizational structure of decision rights concerning IT and the distribution of work. Weil and Ross (2004) suggest that effective IT governance is the single most important predictor of the value generated by IT. Various authors have divided IT governance into groups of archetypes, including decentralized, federal, and centralized (Brown 1997, Magill and Brown 1994, Weil and Ross 2005). Furthermore, scholars have investigated the relationship between organizations’ IT governance design and contingency factors using contingency theory (Brown 1997, Grant and Brown 2005, Sambamurthy and Zmud 1999, Weber et al. 2009, Weill and Ross 2005, Yajiong et al. 2008).

There is no single IT governance type that fits for all forms of organizations. However, contingency theory can be used to recommend a certain form of IT governance for organizations that meet certain contingency characteristics (Figure 2). The two main ideas of contingency theory are illustrated: while the characteristics of an organization, e.g., the allocation of decision rights, impact the organization’s success, the ideal organizational configuration is determined by specific contingency factors.

![Contingency model adapted from Weber et al. (2009) and Umanath (2003)](image)

Figure 2: Contingency model adapted from Weber et al. (2009) and Umanath (2003)

Green IT governance can be defined as an operation model that describes the administration of Green IT initiatives (Molla et al. 2009). Schmidt and Kolbe (2011) adapt the IT governance definition of Weil and Woodham (2002) and characterize Green IT governance as a decision right and accountability framework to encourage environmentally desirable behavior in the sourcing, use, and disposal of IT. As Molla et al. (2009) point out, recent Green IT governance practices vary significantly. Some organizations allocate the responsibilities for governing Green IT to more centralized IT managers; others consider Green IT as a part of enterprise-wide sustainability initiatives and therefore follow a more decentralized approach. Based on the literature, Schmidt and Kolbe (2011) assume that there are three ideal Green IT governance archetypes, which differ in the degree to which decision-making is centralized and are categorized as (1) centralized, (2) federal, or (3) decentralized.

<table>
<thead>
<tr>
<th>Archetype of Green IT governance</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Centralized</td>
<td>Green IT is centralized to a few domains of the IT department. The coordination of Green IT is done by extending job responsibilities, e.g., in the data center or the office environment. The CIO has primary authority. Green IT measures are treated like other IT projects. They are mainly focused on cost reduction by lowering the energy consumption in the data center and/or the office environment. Green IT is of low importance for the company.</td>
</tr>
<tr>
<td>2 Federal</td>
<td>Green IT is coordinated by a designated Green IT manager. Typically, the Green IT manager is a member of the IT department and keeps track of all initiatives, proposes new ideas, and reports to the CIO. The Green IT manager might be a contact partner for the sustainability or environmental manager. Green IT is addressed in the entire IT department and provides first links to other domains. Green IT is of medium importance for the company.</td>
</tr>
<tr>
<td>3 Decentralized</td>
<td>Green IT is coordinated by a designated Green IT committee throughout the various business units of the company.</td>
</tr>
</tbody>
</table>
company following a matrix approach. It consists of a Green IT manager, members from various business units and the sustainability or environmental manager, who reports to the CEO (Chief Executive Officer). The committee holds periodic meetings and reports to a COO (Chief Organization Officer). Green IT activities are an integral part of the company’s sustainability strategy. All aspects of Green IT are considered and evaluated. The Green IT committee might also impact the company’s strategy by developing new Green-IT-related products or services that potentially lead to a competitive advantage. Green IT is of high importance for the company.

Table 1: Description of Green IT governance archetypes adopted from Schmidt and Kolbe (2011)

3 MODEL BUILDING AND HYPOTHESES

From literature review we identified competitive strategy, firm size, organization structure, performance strategy, environmental impact of industry, environmental strategy, IT infusion, and IT diffusion as potential contingency factors for allocation of decision rights in Green IT governance (Figure 3).

![Contingency model for Green IT governance](image)

Figure 3: Contingency model for Green IT governance

Most contingency factors are adopted from research on IT governance because they prove to be also relevant in the scope of Green IT governance. Further contingency factors are added from environmental research.

The competitive strategy of an organization has an influence on the degree of centralization of IT decision making. Tavakolian (1989) distinguishes between three main strategies: defender, analyzer, and prospector. A defender is an organization with a conservative competitive strategy that has a tendency to rely on centralized decision making. Organizations with a moderate competitive strategy relying on federal decision making are called analyzers. A prospector is an organization with an aggressive competitive strategy that attempts to be a pioneer in product or market development; these organizations tend to rely on decentralized decision making (Tavakolian 1989). It seems reasonable that this division of strategies also applies to Green IT governance. While conservative companies will do what is necessary, aggressive companies will try to gain a competitive advantage from Green IT. In this case, decentralized Green IT governance offers the best means for developing such advantages.

The firm size is associated with the degree of IT governance centralization (Ein-Dor and Segev 1982). A larger firm is likely to possess a greater potential for Green IT and be more aware of current IT trends, which makes decentralized Green IT governance more favorable. The organization structure and the degree of IT governance centralization have proved to be related (Olson and Chervany 1980, Ein-Dor and Segev 1982, Sambamurthy and Zmud 1999). It therefore seems reasonable that this overall characteristic also impacts Green IT governance.

Weill and Ross (2005) differentiate between three performance strategies – profit, asset utilization, and growth – and assign them to a continuum of governance modes, ranging from more centralized to more decentralized. A profit-oriented strategy aligns well with centralized Green IT governance, which focuses on the biggest energy consumers, such as the data center or the office environment.
Growth is associated with innovation, which is more likely to be achieved through decentralized Green IT governance gathering multiple business units in a Green IT committee.

The environmental impact is different for each industry and implies specific regulations, stakeholder pressures, technological developments, and environmental risks for the companies (Schaltegger and Synnestvedt 2002). Companies from disparate industries are likely to have differing perspectives on environmental management, e.g., a transportation company vs. a software company. We assume that companies from industries with a higher environmental impact tend to be more control oriented in their environmental management and their Green IT governance than companies from industries with a lower environmental impact.

<table>
<thead>
<tr>
<th>Contingency factor</th>
<th>Definition</th>
<th>References</th>
<th>Green IT governance archetypes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Competitive strategy</td>
<td>Type of engagement in product/market development and commitment to stability</td>
<td>(Tavakolian 1989)</td>
<td>Defender</td>
</tr>
<tr>
<td>Firm size</td>
<td>For example, number of employees or revenue</td>
<td>(Ein-Dor and Segev 1982, Sambarumth and Zmud 1999)</td>
<td>Small</td>
</tr>
<tr>
<td>Organization structure</td>
<td>Degree of centralization of the organization</td>
<td>(Olson and Chervany 1980, Ein-Dor and Segev 1982, Sambarumth and Zmud 1999)</td>
<td>Centralized</td>
</tr>
<tr>
<td>Performance strategy</td>
<td>Enterprise performance objective companies emphasize</td>
<td>(Weill and Ross 2005)</td>
<td>Profit</td>
</tr>
<tr>
<td>Environmental impact of industry</td>
<td>Level of environmental impact by industry</td>
<td>(Schaltegger and Synnestvedt 2002)</td>
<td>High</td>
</tr>
<tr>
<td>Environmental strategy</td>
<td>Enterprise’s approach towards regulations and stakeholder pressures</td>
<td>(Aragón-Correa and Sharma 2003)</td>
<td>Reactive</td>
</tr>
<tr>
<td>IT infusion</td>
<td>Degree to which an organization is dependent on IT to carry out core operations</td>
<td>(Sullivan 1985, Ward and Peppard 2002)</td>
<td>Low</td>
</tr>
<tr>
<td>IT diffusion</td>
<td>Degree to which IT is dispersed throughout the organization</td>
<td>(Sullivan 1985, Ward and Peppard 2002)</td>
<td>Low</td>
</tr>
</tbody>
</table>

Table 2: Contingency factors and their assumed influence on Green IT governance

Strategies for managing environmental activities can be classified along a continuum that ranges from reactive to proactive (Aragón-Correa and Sharma 2003). At one end of the continuum, a reactive posture is a response to changes in environmental regulations and stakeholder pressures (Aragón-Correa and Sharma 2003). Proactive organizations are more likely to decentralize decision making related to environmental issues (Aragón-Correa and Sharma 2003). According to Jenkin et al. (2011), a more proactive environmental orientation encourages the organization to strive towards an elaborated Green IT strategy. Therefore, it can be concluded that proactive organizations implement more decentralized Green IT governance, while reactive organizations tend towards a more centralized configuration.

The levels of IT infusion and diffusion define the importance and the dispersion of IT (Sullivan 1985, Ward and Peppard 2002). They are both related to the centralization level of IT governance (Sullivan 1985, Ward and Peppard 2002). It is reasonable that this also applies to Green IT governance; if IT is of high importance (e.g., in a software company), then Green IT will be too. A high level of diffusion implies a high level of energy consumption by IT and makes more Green IT measures useful. Greater importance and more benefits are likely to be accommodated by decentralized Green IT governance.
From the contingency factors we derived the following eight hypotheses. They are summarized in Figure 4.

**H1:** The competitive strategy correlates positively with the applied Green IT governance archetype.

**H2:** The firm size correlates positively with the applied Green IT governance archetype.

**H3:** The structure of an organization correlates positively with the applied Green IT governance archetype.

**H4:** The performance strategy correlates positively with the applied Green IT governance archetype.

**H5:** The environmental impact correlates negatively with the applied Green IT governance archetype.

**H6:** Environmental strategy correlates positively with the applied Green IT governance archetype.

**H7:** IT infusion correlates positively with the applied Green IT governance archetype.

**H8:** IT diffusion correlates positively with the applied Green IT governance archetype.

![Figure 4: Proposed influence of contingency factors](image)

**4 METHODOLOGY**

**4.1 Questionnaire design**

As shown in Figure 4, eight contingency factors have been deducted. Each will likely be correlated with the applied Green IT governance archetype, which is also formulated by the hypotheses H1–H8. These factors and hypotheses have been used as a basis for the quantitative evaluation of the research model.

The evaluation was performed via a paper-based questionnaire addressed to the chief information officers (CIOs) of German companies. This method was chosen because of the better response rate expected. The respondents are not necessarily experts for all contingency factors but are responsible for the deployment of IT within their company and should be able to provide knowledgeable answers. CIOs should have a widespread knowledge about their company and its environment and bear responsibility for the organization’s IT (Grover et al. 1993). To avoid unintended answers, the questions were conceptualized to be easily understood and unopen to interpretation. The items
The first section dealt with contact information for further questions or the delivery of the research results. The second section included a short working definition of Green IT governance. In the third section, several items (indicator variables), which may appear as effects (indicators) of the latent variables, were conceptualized for each of the eight contingency factors (latent variables) and also for the currently applied Green IT governance archetype (Joreskog and Goldberger 1975). These items cover different characteristics of the questioned company and should be used for applying factor analysis in combination with regression analysis for the evaluation of the model. Finally, the last section asked questions about general company information such as the number of full time employees, industry sector, and annual turnover. The final questionnaire contained three to five items for every contingency factor (latent variable) of the proposed research model. The fact that the survey is used to evaluate a contingency model was not mentioned to the participants in order to avoid adulterated answers. The items in the questionnaire were adapted from various earlier studies, mostly from research on technology acceptance, theory of reasoned action, and theory of planned behavior (Davis 1985, Venkatesh and Davis 2000, Venkatesh and Morris 2003) Due to space constraints, we cannot provide the full questionnaire in this document. However, we present as an example the five items that represent the dependent factor archetype of Green IT governance. The statements had to be rated on a six-point Likert scale ranging from “disagree strongly” to “agree strongly.”

- Item 5: Green IT is coordinated across the entire enterprise
- Item 7: Green IT is only implemented in some areas (e.g., in the data center)
- Item 37: Green IT is discussed in interdisciplinary committees
- Item 40: Green IT is a topic for the board
- Item 43: The implementation of Green IT is very important for our company

The questionnaire was pretested by a panel of seven academic experts who examined the item constructs.

4.2 Data collection and analysis

The paper-based questionnaire was sent out via mail. The participants were asked to return it within a four-week timeframe. Each dispatched questionnaire included a hand-signed cover letter to express appreciation to the participants and a self-addressed envelope. To increase the response rate, a cost-free report of the results was offered. The questionnaire was addressed to 800 CIOs or the executive board of German companies. Five hundred of the addressees belong to the list of companies with the highest annual turnover in Germany; most of them operate worldwide. The remaining 300 companies were selected randomly and are small- or medium-sized enterprises (SME). Names and addresses of the companies’ CIOs were identified through Internet research in order to achieve direct and personal contact.

At first, confirmatory factor analysis (CFA) was applied to reduce the numerous items to their underlying variables (factors) from the contingency model for Green IT governance. This type of factor analysis can be used to evaluate specific hypotheses about structure and relations between the latent variables and indicator variables (Field 2009). All variables (items) were examined regarding their usability for factor analysis and several tests were applied to confirm the quality of the sample. Scientific literature has many views regarding whether a sample size is adequate. However, the most recent research on simulated data indicates that sample size is not a concern if factor loadings of at least four items are greater than 0.6. Factor loadings can be seen as a correlation coefficient between a factor and a specific item (Field 2009). The reliability of factor analysis and individual variables can be examined using the Kaiser-Meyer-Olkin measure of sampling adequacy (KMO) (Field 2009, 2009).
Hutcheson and Sofroniou 1999). While KMO values around 0.5 are barely acceptable (Field 2009), higher KMO values are classified as mediocre (0.5–0.7), good (0.7–0.8), great (0.8–0.9), and superb (above 0.9) (Hutcheson and Sofroniou 1999).

When factor analysis is applied, the consistency of the questionnaire should be checked using Cronbach’s α (CA) (Shelby 2011). Though the Cronbach’s α reliability coefficient can take any value below 1.0 (even negative), only values between 0 and 1.0 can be interpreted meaningfully. The closer the CA coefficient is to 1.0, the higher the internal consistency (Gliem 2003). There is no exact threshold regarding the reliability of the Cronbach’s α coefficient. A number of researchers require a cut-off at 0.80 for a “good reliability,” while others declare a threshold of 0.60 to be adequate (Kline 1998, Malhotra and Birks 2007, Nunnally and Bernstein 1994). In this paper we follow Shelby (2011) and choose a CA of 0.60.

After factor loadings, KMO, and CA delivered adequate results, the extracted factors (factor scores) were then used as variables for linear regression analysis to examine the contingency model for Green IT governance. Regression analysis is extremely versatile and flexible and can be used to reveal quantitative dependency between variables. Specifically, relationship effects between a dependent and one or more independent variables can be quantified and described by applying regression analysis (Field 2009). Furthermore, we tested for non-response bias by testing for late-response bias with a t-test. Although late respondents may differ from non-respondents, this test a common method in IS research.

5 FINDINGS

5.1 Sample profile

The four-week period given to answer the questionnaire was extended two weeks further. We received a total of 71 completed questionnaires, amounting to a response rate of 71/800 = 8.9%. The participating enterprises came from a variety of industries that is representative for Germany: manufacturing (35%), financial services (16%), trade and commerce (16%), and others (33%). The annual turnover and the number of employees indicate that larger enterprises dominate the sample. This matches the distribution of the original addressees. According to the responses, 55.1% of the companies have already applied Green IT activities for a long time, and 51.4% additionally responded that they have acquired much experience in Green IT. Only 30.0% agreed or strongly agreed that they are experts in the field of Green IT. However, 88.7% of the responding companies agreed or strongly agreed that the incorporation of environmental sustainability into their IS is of high importance for their company. There was no significant difference between the means and the variances of early responses and late responses, and therefore we argue that there is little to no non-response bias in our findings.

5.2 Factor analysis

For the dependent factor archetype of Green IT governance and the eight contingency factors (latent variables), five items (statements) have been formulated in the questionnaire. During the analysis, several items turned out to be inappropriate because their factor loadings were far lower than 0.6. Furthermore, some items turned out to be useless because their answers between “strongly disagree” and “strongly agree” could not be assigned to a centralized or a decentralized archetype of Green IT governance. Items (statements) were mostly formulated tending to decentralized Green IT governance, while disagreements with those statements were assumed to aim more towards a centralized Green IT governance archetype. Responses in the middle of the six-point Likert scale (answer boxes three and four) have been assigned with a federal archetype of Green IT governance. Moreover, the rating scale of some had to be inverted for the evaluation process because these items had either been formulated negatively or the items tended to centralized Green IT governance. Within the results of the factor analysis, these items are marked with “inv.”
Our business model is regularly being modified in order to adjust ourselves to new situations. We are always looking for new ideas, solutions, and products. Our company is quite innovative compared to other companies. Competitive strategy

We are always looking for new ideas, solutions, and products. Our company is quite innovative compared to other companies.

Firm size

How many employees (FTE) are in your company? How many people are employed in the IT sector? What is the annual turnover of your company in millions of €?

Organization structure

Our corporate structure is highly decentralized. Our company is spread across regional or global locations. The business units are largely independent in their actions.

Performance strategy

Our business strategy is focused on growth. We are planning to expand into new markets.

Environmental impact of industry

Our company operates in a very energy-intensive and resource-intensive industry. Compared to other industries, our company has a large impact on the environment. In public our influence on the environment plays a tangential role. Our company is strongly affected by environmental regulations.

Environmental strategy

Mainly environmentally friendly technologies are being used in our company. Ideas on environmental protection are supported by all levels of the company. Regarding the issue of environmental protection, our company embodies a role-model function.

IT infusion

The corporate strategy is heavily influenced by the possibilities and limitations of IT. Without the application of IT, we could not hold our position on the market. A failure of our central IT infrastructure means an immediate standstill of almost all key business operations. The proper operation of IT is critical in doing business.

IT diffusion

IT is extensively being used in almost all workplaces of our company. We have at least one private data center in operation. IT is used extensively throughout the enterprise. The IT department maintains many devices.

Table 3: Factor analysis independent factors

The results of the confirmatory factor analysis are listed in Table 3 and Table 4. Although the factor loadings of two items are below the restriction of ≥0.6, they were not excluded from the factor analysis because of their minimal distance (.002 and .012) to the threshold and the presence of at least four items for both variables. The KMO and CA values of all factors vary between very good and acceptable.

Table 4: Factor analysis dependent factor

Calculated factors scores are not listed within this paper but were used for the following regression analysis. Field (2009) also promotes this approach of using factor scores as an additional analysis method. A negative factor score indicates that the company is underperforming with regard to a certain factor in comparison to other companies and vice versa.

Before applying regression analysis using the calculated factor scores, histograms referring to the items of the dependent factor were analyzed to ensure that the overall answers given were not one-
sided, which could be confirmed. Within the following examination, the scope of possible mean values (between 1.0 and 6.0) has been divided into three equally sized segments. Afterwards, a clustering of the mean values of the dependent factor governance archetype into these three segments demonstrated that a federal Green IT governance archetype appears to be applied by 41.43% of the companies. A rather centralized archetype seems to be applied by 34.29% of the participating companies, while only 24.28% apply a decentralized governance approach.

5.3 Regression analysis

This section presents the results of the linear regression analysis, which is an important step within the quantitative evaluation of the proposed contingency model for Green IT governance. In this analysis, missing values have been substituted by means. The result of the regression analysis (Table 5 and Table 6) is that the eight contingency factors explain 49.3% of the variance of the currently applied Green IT governance archetype (R-squared) with significance level of p < .001. In addition, the first column of Table 5 presents the result of a multiple correlation analysis between all independent factors and the dependent factor. This value of R = 0.702 is quite large and demonstrates a high correlation between the independent factors and the dependent factor (Field 2009).

<table>
<thead>
<tr>
<th>R</th>
<th>R-squared</th>
<th>Adjusted R-squared</th>
<th>Standard error of the estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.702</td>
<td>0.493</td>
<td>0.428</td>
<td>0.7512093</td>
</tr>
</tbody>
</table>

Table 5: Model Summary

<table>
<thead>
<tr>
<th>Model</th>
<th>Sum of squares</th>
<th>df</th>
<th>Mean square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>34.013</td>
<td>8</td>
<td>4.252</td>
<td>7.534</td>
<td>.000</td>
</tr>
<tr>
<td>Residual</td>
<td>34.987</td>
<td>62</td>
<td>0.564</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>69.000</td>
<td>70</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 6: Analysis of variance

Of the constructed hypotheses H1–H8, which assumed that each of the eight contingency factors would have a positive effect on the applied Green IT governance archetype, not all can be confirmed. However, hypothesis H6 (environmental strategy) is very strongly supported by the data on a significance level p < .001 and a regression coefficient β = 0.525. Furthermore, hypothesis H5 (environmental impact of industry) is strongly supported by the data (β = 0.246, p < .05). Hypotheses H4 (performance strategy) and H7 (IT infusion) can be considered acceptable with a significance value p < 0.1, while H1 (competitive strategy), H2 (firm size), H3 (organization structure), and H8 (IT diffusion) are not supported by the data (Table 7 and Figure 5).

<table>
<thead>
<tr>
<th>Dependent variable (factor)</th>
<th>Unstandardized coefficients</th>
<th>Standardized coefficients / Beta</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Archetype of Green IT governance</td>
<td>-4.255E-17</td>
<td>.089</td>
<td>.000</td>
<td>1.000</td>
</tr>
<tr>
<td>Independent variables (factors)</td>
<td>Unstandardized coefficients</td>
<td>Standardized coefficients / Beta</td>
<td>t</td>
<td>Sig.</td>
</tr>
<tr>
<td>Competitive strategy</td>
<td>-.033</td>
<td>.110</td>
<td>-.033</td>
<td>-.299</td>
</tr>
<tr>
<td>Firm size</td>
<td>.155</td>
<td>.121</td>
<td>.156</td>
<td>1.279</td>
</tr>
<tr>
<td>Organization structure</td>
<td>-.116</td>
<td>.099</td>
<td>-.117</td>
<td>-.1173</td>
</tr>
<tr>
<td>Performance strategy</td>
<td>.217</td>
<td>.118</td>
<td>.218</td>
<td>1.824</td>
</tr>
<tr>
<td>Environmental impact of industry</td>
<td>.246</td>
<td>.110</td>
<td>.248</td>
<td>2.241</td>
</tr>
<tr>
<td>Environmental strategy</td>
<td>.525</td>
<td>.123</td>
<td>.529</td>
<td>4.258</td>
</tr>
<tr>
<td>IT infusion</td>
<td>.216</td>
<td>.113</td>
<td>.217</td>
<td>1.910</td>
</tr>
<tr>
<td>IT diffusion</td>
<td>.044</td>
<td>.125</td>
<td>.044</td>
<td>.353</td>
</tr>
</tbody>
</table>

Table 7: Coefficient matrix
There could be several reasons why some contingency factors seem to be more relevant than others. However, the two contingency factors with the highest significance levels (environmental impact of industry and environmental strategy) are contingency factors that have been adopted from literature on environmental aspects instead of IT governance. Summarizing the results of the regression analysis, it can be stated that the contingency model for Green IT governance can be partially verified with this quantitative evaluation.

6 DISCUSSION

From the results in the former sections it can be concluded, with certain limitations, that different archetypes of Green IT governance can be explained or predicted with contingency theory and a set of contingency factors.

Our initial research question “Which Green IT governance patterns exist in theory and practice?” can be answered as follows: Green IT governance can be allocated in different positions within an organizational structure. While there are endless possibilities for allocating decision rights, most organizations tend towards one of three archetypes: decentralized, federal, or centralized decision making. We derived these archetypes from the literature on IT governance and were able to confirm with the quantitative analysis that these archetypes can be applied to Green IT governance. Our second research question was “Which contingency factors exist for Green IT governance?” For that matter, we were able to derive eight potential contingency factors from the literature on IT governance and sustainability: competitive strategy, firm size, organization structure, performance strategy, environmental impact of industry, environmental strategy, IT infusion, and IT diffusion. However, in the quantitative analysis only four contingency factors demonstrated a significant impact on the archetype of Green IT governance: environmental strategy ($p < .001$), environmental impact of industry ($p < .05$), performance strategy, and IT infusion (both with a barely acceptable $p < 0.1$). Finally, the last research question, “To what extent do these factors explain the allocation of Green IT governance within organizations?” can be answered as follows: With regression analysis using our proposed contingency factors on the dependent variable Green IT governance, we can explain 42.8% of the variance in the dependent variable.

![Figure 5: Results of regression analysis](image)

There are some limitations to our preliminary findings. First of all, while our proposed contingency factors exhibited good fit within the applied case studies, only half of the derived factors had a significant impact in the quantitative analysis. We can therefore state that additional research has to be
conducted to evaluate whether this is due to poor item constructs or if other factors that help the model gain a higher level of explanation of the dependent factor have to be determined. Furthermore, the number of responses, with a count of 71, is only a beginning. Future research should evaluate our findings with a larger sample size. The sample selection and the applied statistical methods impose specific limitations to the results as well. First of all, our findings can only be representative for Germany, as only German companies participated in the questionnaire. However, results may vary in different regions due to different policies and regulations, economics, or social norms. Limitations also derive from the application of factor analysis. Conclusions are restricted to the sample collected and generalizations of the results can be achieved only if analysis using different samples reveals the same factor structure (Field 2009). Furthermore, dividing participants into chronological groups to test for non-response bias is not necessarily sufficient, as late responses may have different reasons for occurring than non-responses (Mentzer and Flint 1997).

The above findings demonstrate support for our proposed contingency model for Green IT governance. From this we draw theoretical and practical implications for researchers and organizations in the scope of Green IT. Concerning the academic community, we argue that contingency theory can be applied to Green IT governance in organizations. We could once more show that contingency theory is suitable for explaining relationships of contingency factors and organizational structure. While the results from the case study interviews can be seen as purely descriptive explanations of such relationships, our quantitative analysis with factor and regression analysis provided some evidence that contingency factors can also be interpreted as predictors for the allocation of Green IT governance resources. In addition to supporting contingency theory, we were able to create a model for Green IT governance as an artifact. This artifact was evaluated in five case studies and at least partly validated in the quantitative analysis. We thereby contributed to the body of knowledge in the research areas of contingency theory, IT governance, and sustainable information systems.

We also can offer some implications for practice. With an enhanced understanding of how Green IT governance is shaped by contingency factors, organizations may be able to select the most appropriate Green IT governance form to achieve their desired outcomes within specified contexts. For companies that have not yet implemented environmental sustainability into their information-system infrastructure and corporate culture, our model provides a reference for how to coordinate decision making when implementing green measures. Organizations that have already adopted Green IT can benchmark their existing Green governance against the proposed archetype from the model. This should either confirm the applied strategy or provide a strategic direction for future development of Green IT governance.

This paper provides an initial quantitative evaluation of the contingency model for Green IT governance, which could be validated partially throughout the qualitative and quantitative evaluation within the German corporate world. However, these preliminary results require further investigation and validation. Future research should therefore replicate the examination in other countries in order to determine whether the conclusions of this paper are transferable to other parts of the world with different social standards and laws as well as economic and ecological regulations. Furthermore, single items that had to be excluded from the factor analysis due to low factor loadings should be examined. Regarding future evaluations of the contingency model for Green IT governance, these items should be modified or replaced if necessary. Last but not least, other contingency factors should be tested within our proposed model in order to increase its explanatory value.
REFERENCES


