Exploring the impact of a company's web technological development on its innovation activity: a case study of small- and medium-sized enterprises (SMEs) in North Wales

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Abstract This research is to explore the impacts of a company's web technological development on its innovation activity and to estimate the probabilistic impact of technology on levels of innovation, which consist of marketing mix, environmental and organisational innovation. This research was implemented in North Wales, UK using a relatively small purposive sample ($n = 68$) of SMEs as a case study. A mixed-method analysis was employed combining phenomenology and positivism. The phenomenological aspect was implemented by analysing respondent interview texts using Content Analysis. Positivist research was applied to the survey questionnaires by applying correlation and a Logit analyses. The findings indicate an increase in company Web technological development corresponding to an increase in company innovation activity. Although, it seems consistent with the relevant literature, however, technology did not create environmental innovation but merely created new marketing-mix innovation such as product, price, promotion and process innovation. Due to the nature of the purposive sampling technique employed, this case study carries limitations. A purposive sampling technique is known as non-probabilistic sampling technique in the literature. The aim is not to randomly select samples from the SMEs population with the intention of making generalisations, but to serve as an initial empirical exploration as a case study to guide further research with a larger sample size. This study carries originality in relation to the methodology, which can be replicated with larger samples. Using

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actual values, the findings of Logit model can also be used to directly calculate the impact of technological levels on SMEs' innovation activity.

Keywords Technology · Innovation · Marketing mix · Case study · Small- and medium-sized enterprises

Background of the study

The European economy has undergone structural change. The change has been reflected in the significant contribution of the services industry to gross national product. The service industry has increased its share in the world economy since the last decade (OECD 2011; Barrell et al. 2000). Innovation in the service industry is considered to be one of the main driving forces of the performance in enterprises (Jiménez-Jiménez and Sanz-Valle 2011). Relevant literature (e.g., Sapprasert 2010) also indicates that the use of information technology (IT) accounts for the higher levels of performance experienced by firms in the service industries. More empirical results (Koellinger 2008) show that IT development including Internet-enabled (product and process) innovation is positively associated with the higher levels of performance experienced by firms.

Although there has been a variety of past conceptual and empirical research on service quality and innovation (Lindic et al. 2011; Agarwal and Selen 2011; Sapprasert 2011; West 2011; Amara et al. 2009; Fagerberg 2006; Soriano 2001; Greenhalgh and Gregory 2000; Licht and Moch 1999), however, the impact of technology on firms' varietal innovation has received little attention in the innovation literature (Gremyr et al. 2010; Amara et al. 2009). The aim of this research is to explore the impacts of a company's web technological development levels on its innovation activity and the likely (probabilistic) impact of technology used by SMEs on their innovation. This research was implemented in North Wales, UK using relatively small and purposive samples of SMEs as a case study.

Survey questionnaires (Appendix 1) were distributed to SME participants. The participants were then asked about the levels of their Web technology and innovation activity within their firms. In this paper, a company's level of technology is narrowly defined as a company's Web-development technologies which have been used widely to communicate its commercial activity on the Internet following earlier studies (Robson and Achur 2011; Krishnan and Saldanha 2010; Patrick and Dotsika 2007).

Following previous innovation studies (Godin 2008), a broader taxonomy encompassing all issues concerning innovation, such as artistic, scientific, cultural, social or individual innovations, will not be explored in this research. Instead, innovation in this study is defined narrowly in terms of Web technological development, relating particularly to marketing-mix innovation. Marketing-mix innovation consists of product, process, price, physical evidence, process and people innovation, which together are known as the 7Ps (Table 1) in the marketing literature (Kotler 1976; Booms and Bitner 1981). In addition to the marketing-mix innovation, organisational and environmental innovation was also included in this

research following earlier studies such as “First findings from the UK Innovation Survey 2011” (Robson and Achur 2011; DTI 2001).

The theoretical explanation of the relationship between Web technology and marketing-mix innovation has been documented vigorously in both the theoretical and empirical literature (Krishnan and Saldanha 2010; Koellinger 2008; Patrick and Dotsika 2007). The explanation is that Web technological development through e-commerce and online presence offers customers a speedier process, a new service to deliver products, and more efficient processing. Hence, Web technological development relates directly to marketing-mix innovation rather than other types of innovation.

Table 1 reveals that an SME company can create innovation using the marketing-mix variables. For example, it can offer a new price innovation. Many SMEs have been lost to competitors because they priced themselves wrongly. However, by responding to the needs and behaviours of customers, price discrimination can be created to gain back their market shares. This price discrimination innovation is simply defined as the practice of setting different prices for the same product in different segments of the market, such as providing different pricing for different ages, for different opening times, or for different educational backgrounds.

Analogously, this innovation construct can be applied to other marketing-mix variables (Table 1), such as people and process innovation. This process innovation can also be captured in organisational (internal) innovation (Appendix 1: Survey Questionnaires) since both types of innovation are intended to improve working practices, which also leads to more time efficient processing.

Relevant literature (Hitzler et al. 2010; O'Reily 2009; Møller and Schwartzbach 2006; Markoff 2006) indicates that the development of Web technology (Fig. 1) started with Web 1.0 as the first generation of the Internet. During this phase, the focus of the technology used by SMEs was on merely establishing SMEs' presence on the Web, thus generating customers' and suppliers; awareness of the company electronically. Technological areas centred on protocols such as Hypertext Transfer Protocol (HTTP), open standard markup languages such as Hyper Text Markup Language (HTML), Internet access through Internet Service Providers (ISPs), the first Web browsers, Web-development tools, Web-centric software languages such as Java and Javascript, the creation of Web sites, the commercialisation of Web business models, and the growth of key portals on the Web. At this initial stage, most SMEs simply delivered static information online in which both customers and producers could only view Webpages with static content.

Following Web 1.0, the second generation of Web technology followed with the introduction of Web 2.0, which has recently been employed by SMEs to communicate their commercial presence (Krishnan and Saldanha 2010; Patrick and Dotsika 2007). This includes more recent platforms such as social networking sites, communication tools and others that emphasise online collaboration and sharing among users. Web 2.0 allows for the production of user-generated content (read-write) in which the community (producers, customers, suppliers and government) consumes as well as contributes information through sites such as Flickr, Twitter, YouTube, Digg, Skype, Wordpress, etc. Key technological features of Web 2.0 include Folksonomy: free classification of information, rich user

Table 1 Marketing-mix variables

Product	Price	Place	Promotion	People	Physical evidence	Process
Quality	Level discounts	Location	Advertising	Personnel	Environment	Policies
Features and options	Level allowances	Accessibility	Personal selling	Training	Layout	Procedures
Brand name	Payment terms	Distribution channels	Sales promotion	Commitment	Colour	Mechanisation
Packaging	Differentiation	Distribution coverage	Publicity	Incentives	Noise level	Customer involvement
Product line	Quality price interaction, etc.	Outlet locations	Exhibition	Appearances	Tangible clues, etc.	Customer direction
Warranty		Inventory levels	Search engine optimisation	Interpersonal behaviour		Flow of activities, etc.
Service level, etc.		Carriers, etc.	Public relation, etc.	Attitudes, etc.		

Source adapted from Kotler (1976), Booms and Bitner (1981)

Fig. 1 The development of Web technology used by SMEs. *Source* adapted from Hitzler et al. 2010, O'Reily (2009), Møller and Schwartzbach (2006), Markoff (2006)

experience, user as a contributor, long tail, user participation, basic trust and dispersion.

More recent literature (Hitzler et al. 2010; O'Reily 2009; Møller and Schwartzbach 2006) indicates that Web 3.0 technology or the Semantic Web constitutes the future generation in Web technology, in which the technology optimises information from diverse sources to produce information profoundly beyond the dynamic pages of Web 2.0 such as allowing producers and customers to interact with each other in real time (Table 2). Web 3.0 uses the same format as Web 2.0 but it is a more intelligent Web format using Semantic Web (the meaning of data), microformats, natural language search, data mining, personalisation such as iGoogle, machine reasoning, autonomous agents, and artificial intelligence to facilitate the production of information and more productive and intuitive user experiences. Hence, the Semantic Web provides a communal framework that allows data to be shared across applications, enterprises, and community boundaries.

Although Web technologies are available to all firms, not all firms possess the same levels of technology. However, the majority of the theoretical and empirical literature reveals (Krishnan and Saldanha 2010; Koellinger 2008; Patrick and Dotsika 2007; Clausen 2008; Corso et al. 2001) that although technology levels differ among firms, the relationship between Web technology adoption and innovation is positive across all variety of industries ranging from the commercial and professional services, retailing, food beverages and tobaccos to banks. For example, basic Web technologies have significantly influenced the ability of SMEs across sectors to innovate and expand to take advantage of new opportunities from e-commerce (Krishnan and Saldanha 2010; Koellinger 2008; Patrick and Dotsika 2007).

There are diverse definitions of 'innovation' (McAdam et al. 2004), which generate ambiguity. Correspondingly, this study defines innovation as 'something new or improved' (Baregheh et al. 2009). Furthermore, they classify three types of innovation, namely marketing-mix innovation, organisational innovation and environmental innovation. Using this taxonomy, an SME company (which implements internal organisational innovation to improve processing systems) also undertakes process innovation at the same time (as a part of marketing-mix innovation). Hence, internal organisational innovation and marketing-mix innovation facilitate each other empirically.

People and programme innovation, as a part of marketing-mix innovation, could also fit into both organisational and environmental innovations. However, earlier studies reveal that marketing-mix innovation has a stronger association with a

Table 2 Characteristics of Web technology

Web 1.0 (first generation)	Web 2.0 (second generation)	Web 3.0 (third or future generation)
Focusing on companies (45 million users in 1996)	Focusing on communities (1 billion users in 2006)	Focusing on individuals (10 billion users in 2015)
Read-only Web	Read-write Web	Portable-personal Web
Static homepage	Semi-dynamic Blogs	Dynamic widgets
Owning content	Sharing content	Semantic content
HTML	XML, RSS	User Behaviour
Directories (Taxonomy)	Tagging (Folksonomy)	User engagement
Britannica online	Wikipedia	Drag and drops mashups

Source adapted from Hitzler et al. 2010, O'Reilly (2009)

company's Web technological development than other types of innovations. This is because marketing-mix innovation is most clearly associated with an SME's improved sales and competitiveness, as action taken by an SME's to enhance its product and process innovation (as a part of marketing-mix innovation) would lead to improved competitiveness when facing rival companies in a highly competitive environment.

The reason for 'innovation leading to enhanced competitiveness' is that the performance implications of Web technological development are mediated by innovative activities such as an enhanced product quality, a simplified processing structure, more competitive pricing, and friendly employees and supportive customer service teams. However, the performance implications vary across different types of innovation, depending on both firm-internal and market-specific factors (Koellinger 2008). In addition to this, Koellinger (2008) taxonomises several types of innovative activity that were caused by Internet-based technological development, such as product and process innovation. Correspondingly, marketing-mix innovation is arguably one of the more dominant factors which relate to a company's Web technological development.

Earlier research on technology (Oakey and Cooper 1991) revealed that basic technologies significantly influence the ability of small firm entrepreneurs to innovate and expand into new businesses. Using data from a sample of 7,302 European enterprises, Koellinger's (2008) study supported earlier empirical studies that Internet-based technologies were an important enabler of innovation in 2003. Other research (such as Berman and Hagan 2006; Lyu et al. 2009), which investigated the relationship between IT, innovation and firm performance, came to similar conclusions. That said, most of the empirical results show that innovation mediates the effect of Web technological development on the performance of SME firms.

In this research, marketing-mix innovation consists of product innovation, price innovation, place innovation, promotion innovation, process innovation, people innovation and physical evidence innovation. For example, product innovation as part of marketing-mix innovation is defined as the creation of new commodities (products and services) or a considerably improved competence of existing commodities. In contrast, process innovation is defined as new or enhanced production process or

support to produce the commodities. Following relevant literature (Carney and Ryan 2010; DTI 2001), there are additional innovation classifications such as organisational innovation and environmental innovation (Fig. 2). For a detailed explanation, please refer to Appendix 1 (Survey Questionnaires).

This research further breaks down product innovation into two parts, functional and aesthetic. A score produced for functional product innovation indicates to what extent the company implemented a product strategy which has not been used before, such as launching new or significantly improved products. The concept relates more to improving core or functional products. In contrast, an aesthetic innovation score refers to what extent the company implemented a new packaging strategy and created a new and different aesthetic design. It relates solely to the aspects of packaging.

Since people are a main component in any enterprises, a people innovation score can be produced to show how well a company implemented an innovation centrally

Fig. 2 Types of innovation

based around its personnel or introduce a new people strategy which has not been employed before, such as recruiting more talented personnel and training staff to create a competitive advantage, taking into account that people are front-office elements of any service that customers can interact with. Price innovation score relates to the extent to which the company has introduced a new pricing strategy which has not been used before, such as price discrimination, discounted schemes, rebates, etc. Place innovation score refers to what extent the company has implemented new distribution channels, additional branch offices, exclusive retailing, etc. Process (internal) innovation score relates to the extent the company has improved internal production systems such as lean manufacturing, just-in-time production and total quality management. Process (external) innovation score relates to the extent the company has improved external distribution methods, such as new supply chain management, etc., to deliver goods and services to customers.

Organisational (external) innovation score refers to the extent the company has implemented a new (external) organisational strategy such as strategic alliance, merger, etc. Organisational (internal) innovation score relates to the extent the company has implemented a new (internal) organisational strategy such as new working practices, teamwork activities, etc.

There are three types of environmental innovation, namely product, energy and legal innovation. Environmental (product) innovation score refers to the extent the company has improved products benefitting the environment, such as reduced energy and decreased CO₂ ‘footprint’ per unit of outputs. Environmental (energy) innovation score relates to the extent the company has improved production systems benefitting the environment, such as reductions in soil usage, water, noise and air pollution, recycled waste, and materials. A further score category is environmental (programme) innovation, which relates to the extent the enterprise has implemented environmental programmes in response to government regulation, community demands, taxes on pollution and practices considered to be optimal.

Research methodology and limitations

This research employed a mixed-method analysis by combining both phenomenology and positivism. The phenomenological aspect was implemented by analysing the respondents’ interview texts using Content Analysis, which can be defined as a methodology for making critical inferences by systematically identifying specified characteristics of interview texts (Krippendorff and Bock 2008; Krippendorff 2004; Babb 2003; Berelson 1972). Further, the interview texts were examined in relation to their authenticity, thematic coding and structural meaning.

The positivist side of the research consists of conducting survey questionnaires (primary data) and applying correlation analysis and the Logit model to the data. Since the primary data do not consist of metric scales but a number of categories, the Logit model can be used to explore the relationship between a categorical-dependent variable (such as innovation activities or levels) and a categorical-independent variables (such as number of staff employed, a company’s annual turnover, a company’s technological levels and a company’s orientation or operational scope).

Essentially, the purpose for using a mixed-method approach by combining the qualitative and quantitative paradigms is to enhance the quality of the end results (Driscoll et al. 2007; Greene et al. 1989). In addition, by analysing different components of the research (survey questionnaires and interview texts) in a cohesive way to address a defined set of research questions, a more robust solution might be found. It is even quoted in the literature (Sydenstricker-Neto 2010) that one of the benefits of using a mixed-method approach is the ability to provide additional qualitative information, which provides key insights into quantitative findings. In short, the mixed method is a way to come up with creative alternatives to ‘traditional’ ways of doing research.

The philosophy of pragmatism (Sydenstricker-Neto 2010; Driscoll et al. 2007; Greene et al. 1989) argues that using a mixed-method approach is appropriate for finding ‘the truth’ regardless of any philosophical or paradigmatic assumptions. The combination of these methods should provide more robust and comprehensive findings. Combining both quantitative and qualitative analyses provides the opportunity for a researcher to efficiently generate a greater understanding of the phenomena under investigation, because every method has inherent weaknesses and strengths.

Correspondingly, correlation analysis and the Logit model will be employed to complement Content analyses. A correlation-coefficient analysis is defined here as a statistical measurement of the relationship between two variables. The correlation coefficient (r) ranges from -1.0 to $+1.0$. The closer r is to $+1$ or -1 , the more closely the two variables are related. A correlation of -1 indicates a perfect negative correlation, while a correlation of $+1$ indicates a perfect positive correlation, meaning that both variables move in the same direction together (Bryman 2012; Binsardi and Green 2012).

Following the correlation-coefficient analysis, the Logit model can be used for predicting the outcome of a categorical dependent variable based on one or more predictor variables. Algebraically, a Logit (log odds) model of π can be produced using the following equations:

$$\text{Odds} = \frac{\pi}{\pi - 1} \quad (1)$$

$$\log \text{it}(\pi) = \log(\pi) - \log(1 - \pi) \quad (2)$$

The dependent variable in the Logit model is dichotomous. It takes the value 1 with a probability of success π , or value 0 with a probability of failure of $1 - \pi$. In the above equations, the base of the logarithm model used is 10; however, the natural logarithm ($\ln$) is the most frequently used in the empirical literature (Agresti 1996; Kleinbaum 1997). Accordingly, the Logit model of any number π can be provided algebraically by applying the following Logit equations:

$$\log \text{it}(\pi) = \ln\left(\frac{\pi}{\pi - 1}\right) \quad (3)$$

$$\ln\left(\frac{\pi}{1 - \pi}\right) = \delta_0 + \delta_1 X_1 + \delta_2 X_2 \quad (4)$$

Following the Eqs. 3 and 4, the empirical literature (Hosmer and Lemeshow 2000; Menard 1995; Kleinbaum 1997) reveals that a simple Logit model (with a single predictor variable of X) can take on the following forms:

$$\frac{\pi}{1 - \pi} = e^{\delta_0 + \delta_1 X} \quad (5)$$

$$\pi = \frac{e^{\delta_0 + \delta_1 X}}{1 + e^{\delta_0 + \delta_1 X}} \quad (6)$$

where π stands for the probability that the dependent variable equals 1, δ_0 for constant, δ_1 for a parameter coefficient of X and e for the base of the natural logarithm.

The literature (Allison 2012, Hosmer and Lemeshow 2000) reveals that there are several reasons for using a Logit model, such as, it can predict the probability of an event occurring ($\pi = 1$) based on a list of independent variables. By relating the concept of a Logit model to the aims of this research, the intention is to explore the probability of having higher levels of innovation activity. For example, in relation to this research, it is expected that the Logit model will provide answers to what are the most important aspects contributing to higher levels of innovation activity in a company in relation to a company classification (such as number of staff employed, annual turnover, orientation or operational scope and a company technological development). Hence, the Logit model could also be employed to formulate factors or variables that may determine higher levels of innovation activities.

The aim of this paper is to explore the impacts of a company's web technological development on its innovation activity among SMEs based in North Wales, UK. Increasing the level of a company's innovation activity will enhance its service quality delivery leading to higher sales and profitability. The companies were selected using a purposive sampling technique because of practicality reasons, time and resource limitation. Following relevant guidelines (European Commission 2012, 2003), there are several criteria which need to be considered when determining whether a company is an SME, such as number of employees in the company, and the company's annual turnover. These criteria were used as a guide to include SMEs to follow a purposive sampling technique.

Relevant methodological literature (Bryman 2012; Binsardi and Green 2012) indicates several purposive sampling techniques such as homogeneous sampling, typical case sampling, extreme case sampling, critical case sampling, total population sampling, maximum variation sampling (MVS) and expert sampling. In this study, a MVS method was employed. The justification for utilising such a technique is to capture a wide range of perspectives relating to SMEs' use of technology and innovation depending on the size of the company: thus, enterprises of varying size, ranging from very small to medium, were included in the study. The main purpose for using MVS is to achieve a variety of insights by scrutinising the respondents in the context of multiple research paradigms to identify common patterns that are evident across the samples.

Over a period of 6 months, about 350 survey questionnaires and interview questions were sent to small- and-medium-sized enterprises in North Wales. The companies were asked to disclose their types of SME category, business activity or their standard industrial classification (SIC) as well as the type of Web technology, which has been used by the company. This study follows the UK Standard Industrial Classification of SMEs based on 2007 classification (ONS 2012; DTI 2001) by categorising business establishments according to type of economic activity as well

as classifications such as number of employees, annual turnover and the company's orientation or scope, whether this be local, regional or international. Initially, a pilot study was implemented by sending the questionnaires by e-mail to selected respondents. This acted as a pilot (trial) survey to determine what prospective participants thought about the questionnaires. Their suggestions for improvements were taken on board and improvements carried out. The survey questionnaire consists of 19 questions, while there are interview (semi-structured) questions based on a scripted set of two discussion topics.

Out of 350 survey questionnaires, 71 survey questionnaires were responded to; however, only two companies were available to participate voluntarily in the interview and this has resulted in a 20.29 % response rate ($=71/350$). After cleansing, stratifying the samples and eliminating incomplete questionnaires, 68 survey questionnaires were valid and used in this study with the following sampling breakdown (Table 3). The most frequent reason given for declining to participate was the company's limited time and resources to participate in the research as well as the company's fear of revealing their innovation activity and trade secrets.

Due to the nature of a purposive sampling technique employed in this study, this case study carries methodological limitations. A purposive sampling technique is known as a non-probabilistic sampling technique in the literature, in which the aim is not to randomly select samples from the SMEs population with the intention of making generalisations but to produce an initial empirical exploration (such as a case study in North Wales) to guide further research with a larger sample size. In addition, since this study employs a mixed methodology, a purposive sampling technique is justified, following the guidance of relevant literature (Bryman 2012; Patton 1990).

Empirical findings

Table 4 indicates that the majority of the SME participants (72.06 %) are classified as micro enterprises with an annual turnover of <2 million Euros. These are followed by small enterprises (25.00 %) with an annual turnover of between 2 and 10 million Euros. 2.94 % of the companies are medium-sized enterprises with an annual turnover of between 10 and 50 million Euros. Although the data were skewed to the right because the mean of annual turnover is bigger than the median, however, by analysing a variety of SMEs with different levels of turnover, a MVS was optimised to capture a wide range of perspectives relating to SMEs' technological and innovation levels.

Table 3 Stratified purposive samples of SMEs by staff number

Strata (variation)	SME classification	Frequency	Percent
<10 staff	Micro enterprises	45	66.18
Between 11 and 50 staff	Small enterprises	21	30.88
Between 51 and 250 staff	Medium-sized enterprises	2	2.94
Total		68	100.00

MVS is also known as a ‘maximum diversity sampling’ or ‘maximum heterogeneity sampling’ (Goslin 2013; Binsardi and Green 2012; Maykut and Morehouse 2000). This is defined as a type of purposive sampling in which participants are chosen on the grounds that they are as different as possible from one another. MVS is useful in situations where a random sample cannot be drawn because the sample size is relatively small. The purpose of MVS is to capture a wide range of phenomena related to SMEs’ Web technological development and innovation activity. The goal of this is not to recruit random participants and produce generalisable findings, but rather to explore a range of phenomena to inform further studies. It is even cited in the literature (Goslin 2013; Binsardi and Green 2012; Maykut and Morehouse 2000) that when sample sizes are relatively small, MVS can be more representative than a random sampling technique. Correspondingly, instead of seeking representativeness through randomness and equal proportion of SME participants, this study employs MVS by including a wide range of extremes of SMEs from different strata, such as different annual turnovers—micro, small- to medium-sized enterprises (Table 4)—and different industrial classifications—namely, the food service, accommodation, entertainment and recreation (Table 5).

Using these stratifications (Tables 4 and 5), MVS has been achieved with regard to the SMEs’ technology and innovation differential. By investigating SME samples across different stratifications this study intended to uncover the differential aspects of technology and innovation across different strata. However, proportional stratifications (similar percentages) cannot be achieved because of limited respondent participation. From the overall number of survey questionnaires sent out (350), and after eliminating incomplete questionnaires and filtering the questionnaires from five Likert scales into dichotomous scales (two scales; disagree to agree), the final number of valid responses was only 68.

From 68 SMEs, only two SME respondents were willing to participate in the qualitative analysis (interviews). This relatively small number of respondents was due to the fact that they were busy with their managerial commitments.

Table 4 SME participants stratified by their annual turnover

Strata (variation)	Classification	Frequency	Percent
<2 million Euros	Micro enterprises	49	72.06
Between 2 and 10 million Euros	Small enterprises	17	25.00
Between 10 and 50 million	Medium-sized enterprises	2	2.94
Total		68	100.00

Table 5 SME participants stratified by their standard industrial classification (SIC)

Standard industrial classification (SIC)	Frequency	Percent
Food service activity (SIC 9b)	41	60.29
Accommodation (SIC 9a)	24	35.29
Entertainment and recreation (SIC 17b)	3	4.41
Total	68	100.00

Accordingly, they had little time to respond to surveys. Unfortunately, this has impacted negatively on the response rates, which is a common issue for survey studies (Fogliani 1999). Correspondingly, this research employed two respondents to perform qualitative analysis. It is common for qualitative analysis to have a relatively small number of respondents, as qualitative analysis emphasises rigorous insight rather than numerical classification as is the case with quantitative analysis (Bryman 2012; Binsardi and Green 2012; Krippendorff 2004).

In this study, the respondents were not asked about the characteristics of their individuals, instead the survey focused on the demographics of the company (whether micro, small and medium size of SMEs). A simple protocol was employed to test the survey questionnaire (a pilot study) to ensure linguistic simplicity. Following the pilot study, 350 survey questionnaires were sent to micro to medium SMEs in North Wales (Deeside and Wrexham Industrial Parks) along with a covering letter. It was stated in the cover letter that in return for their participation in the survey, the final findings will be distributed to them when the research was finished.

Relevant literature (Binsardi and Green 2012; Gibbons and Chakraborti 2003) states that to investigate associations between variables, several methods can be used in quantitative analysis such as Chi-Square analysis (χ^2) and correlation analysis ($=r$). This study uses correlation analysis using the Spearman rho. The Spearman rho is used instead of Pearson coefficient because of the ordinal data collected, which can be categorised in a five continuous scale from low to high (Appendix 1).

Table 5 shows the SME participants classified by their activity according to SIC following standard classification (ONS 2012; European Commission 2012). The majority of SME participants (60.29 %) are restaurants ('Food Service Activity'). This is followed by hotels and bed and breakfasts ('Accommodation') (35.29 %). The minority (4.41 %) comes from sport and leisure centres ('Entertainment and Recreation'). Although the findings represent the SMEs who participated in the study but, it is expected that they will further reflect the service sector of North Wales SMEs, as shown in the variety of participants' industrial classifications from hotels, restaurants and leisure centres. Hence it is expected that an optimal variation will be reached.

As stated earlier, the lower-than-expected response rates from the participants were due to time and resource limitations of the SMEs, as well as their reluctance to reveal their trade innovation secrets. This phenomenon reinforces the findings of previous studies (Fogliani 1999), which have shown that most companies are reluctant to participate in survey exercises unless it is required by law (such as participating in governmental censuses) because of unwillingness to disclose trade secrets.

In the above table, Q_4 is the level of Web technology, Q_6 is product (functional) innovation score, Q_7 is product (aesthetic) innovation score, Q_8 is price innovation score, Q_{15} is environmental (product) innovation score and Q_{16} is environmental (legal) innovation score.

To measure the internal consistency of the survey questionnaires, Cronbach's α was employed. Cronbach's α can be used to measure the 'internal consistency' of how closely related a set of items (Questions 6–19) are as a group (innovation questions). A relatively high value of α is often used as evidence that the items measure an underlying construct (Field 2013; Binsardi and Green 2012).

To measure innovation activity, this study devised a 14-question questionnaire (Questions 6–19: Appendix 1). Each question contains five scales ranging from 1 to 2, 3, 4 and 5, with one meaning the lowest/least/minimum and five indicating the highest/fullest/maximum. To understand whether the questions in this questionnaire all reliably measure the same latent variable of innovation, five scales were constructed to which a Cronbach's α (Table 10, Appendix 2) was then run on a sample size of 68 respondents. The Cronbach's α reliability coefficient normally ranges between 0 and 1. However, there is actually no lower limit to the coefficient. The closer the Cronbach's α coefficient is to 1.0 the greater the internal consistency of the items in the scale (Field 2013; Binsardi and Green 2012; Carmines and Zeller 1981).

Column 7 (Table 10, Appendix 2) presents the value that Cronbach's α would be if that particular item was deleted from the scale. The findings indicate that the removal of any question, except Question 18, would result in a lower Cronbach's α . Therefore, it is not recommended to remove these questions. However, removal of Question 18 would lead to a small improvement in Cronbach's α . In addition, the corrected item-total correlation value was relatively low (0.112) for Question 18.

Overall, the findings reveal that the reliability coefficient for the set of questions (6–19) was adequately robust because of being higher than 0.70. That said, the overall questions reflect different underlying 'innovation' structures, hence, the questions are consistent and reliable for measuring the same innovation construct. A Cronbach's α of 0.70 is considered acceptable. Although the overall Cronbach's α s are acceptable, care should still be taken since this study employed a relatively small sample ($n = 68$).

SPSS findings of Table 6 reveal that a significant correlation exists between the SMEs' technology (Web technological development) and both Environmental (Product and Energy) Innovation and Product (Functional and Aesthetic) Innovation Scores. The coefficient correlations are r equals 0.682, 0.641, 0.602 and 0.540, respectively. The correlation coefficients are significant at a 1 % level. These findings indicate that the more developed the SMEs' technology was, as reflected in their Web technology (from Web 1.0 to Web 2.0), the higher the SMEs' innovation activity scores were. In addition, a significant association also exists between the company's Web development and its Price Innovation Score ($r = 0.450$), although the coefficient is significant at only a 0.05 level.

All the above correlation coefficients (r) are significantly positive, which indicates that an increase in the company's Web technological development corresponds to an increase in the company innovation levels. However, it is interesting that few SMEs have not used the Internet or Web technology at all (5.90 %, as shown in Table 6). Although most SMEs employ Web 2.0 technology (23.50 %) and Web 2.0 technology and e-commerce (32.40 %), 38.30 % of the SMEs use Web 1.0 technology, in which SMEs publish their existence online with read-only content and static Web sites. Accordingly, final customers, suppliers and government could not engage and interact through social media, etc.

The correlation coefficient used in this study is not strictly causal since the company level of Web technology was not the only variable which affects innovation activity. As indicated by the relevant literature, innovation also depends on several internal and external variables (Fagerberg and Sappasert 2011), such as

knowledge base within the organisation, technology, research development, managerial perception, levels of human capital in the company, the industry infrastructure, etc. Hence, innovation is a multilevel phenomenon (Srholec 2011), which depends not only on the internal characteristics of firms, but also upon the external environment within which firms operate, such as national economic, technological, institutional conditions and the industry infrastructure.

Although Web technology drives innovation, the reverse is also empirically possible. That said, innovations may facilitate and impact further upon the development of SME's Web technology. The development of innovation concerning marketing mix may drive SMEs to integrate their systems further so as to enhance their Web technologies. Hence, to ascertain the direction of empirical causality (the direction of the arrow—Fig. 3), a test of causality could be employed.

Figure 3 reveals that there are several empirical possible cause-and-effect scenarios (1, 2, 3 and 4). Scenario 1 indicates that an increase in the company's Web technological development leads to a rise in the company's innovation activity. Conversely, SMEs' innovation may also facilitate and impact on the development of their Web technology (Scenario 2). That is, the development of innovation activity (such as marketing-mix innovation) drives SMEs to further integrate their technological systems so as to enhance their Web development. Meanwhile, Scenario 3 shows how a company's Web technological development can drive an increase in its innovation activity, and how this can in turn further boost the company's confidence to develop its Web technology. Scenario 4 indicates that X and Y are independent of each other. In practice, this would mean that a company's Web technological development does not affect its innovation activity, and likewise that its innovation activity does not drive its Web technology.

There are two types of test which can be utilised to empirically investigate direction of causality, namely the Granger test (1969) and Sims test (1972). Since both tests provide similar answers, a Granger test was employed in this study. According to Granger (1969), unidirectional causality between *X* (technology) to *Y* (innovation) exists (Scenario 1) if in a multiple regression of *Y* on lagged *Y*_s and lagged *X*_s, the parameter coefficient of lagged *X* is significant. Conversely, Scenario 2 will materialise if a multiple regression of *X* on lagged *X*_s and lagged *Y*, the parameter coefficient of lagged *Y*, is significant. The equation for this can be stated as follows:

Table 6 The coefficient correlation (*r*) and the coefficient determination (*r*²) between the SMEs' technological levels and other variables

	Q4 <i>r</i> (Coef. correlation)	<i>r</i> ² (Coef. determination)	Degree of association (ranking)
Q ₁₅	0.682**	46.51 %	1
Q ₆	0.641**	41.09 %	2
Q ₇	0.602**	36.24 %	3
Q ₁₆	0.540**	29.16 %	4
Q ₈	0.450*	20.25 %	5

** Means the correlation is significant at the 0.01 level (2-tailed)

* Means the correlation is significant at the 0.05 level (2-tailed)

Fig. 3 Path analysis

$$Y_t = \sum_{i=1}^n \alpha_i X_{t-i} + \sum_{j=1}^n \beta_j Y_{t-j} + v_{1t}$$

$$X_t = \sum_{i=1}^n \lambda_i X_{t-i} + \sum_{j=1}^n \delta_j Y_{t-j} + v_{2t}$$

The findings of the causality test (Table 11, Appendix 2) indicate that there is unidirectional causation from X to Y (Scenario 1). This shows that SMEs' development of Web technology has driven their product innovation levels. The test is significant at a 0.01 level. However, the reverse test also supports a marginally unidirectional causation from Y to X (Scenario 2). However, the reverse was only significant at a 15 % level. In other words, the 'initial' impact of Web technology on the product innovation was much more significant (at a 1 % level) than the 'reverse' impact of product innovations on the development of Web technology (at only a 15 % level). However, caution should be taken in regard to these conclusions, as most statisticians choose a level of 1 or 5 % as significant for many applications (Binsardi and Green 2012; Kline 2004; Moore and McCabe 2003).

Details of the Granger test can be viewed in Table 11 (Appendix 2). One possible empirical explanation of the findings is that the implementation of Web technology has facilitated SMEs' innovation activities (it was significant at a 1 % level) by offering quicker e-commerce processing, and providing new online services such as tracking order online. Following this implementation of initial Web development, since most SMEs have spent a considerable amount of capital for the development of their Web technological capacities, they do not wish to incur further expenses to enhance their Web development. That is why the impact from innovation activity to technological development was not strong despite being marginally positive (it was significant at only a 15 % level). This suggests that the development of innovations may to some extent also drive SMEs to enhance their Web technology. However, care should be exercised when analysing the data since it used 'perceived' values provided SME's participants, not the 'actual' values of (1) SME's Web technological development, as, e.g., indicated by financial expenses made by SME participants on Web technological development, and (2) SME's innovation activities, as, e.g., indicated by the number of innovations created by SME participants. However, to analyse the actual values, micro firm-level data from individual SMEs would be required.

Although there have been studies using macro (aggregated) data (Fagerberg and Srholec 2008b), unfortunately, using mere statistical analysis to empirically examine the impact of technology on innovation will be challenging at a micro (firm) level. This

is because of differential measurement issues as there is no aggregated data across the SMEs which is directly available to link both variables. Accordingly, to investigate comprehensively the link between technology and innovation and acquire a comprehensive overview of the role played by technology, a cross-disciplinary methodology is required as no single methodology comprehensively covers all aspects of innovation (Fagerberg et al. 2006; Fagerberg 2003). Following these arguments, qualitative analysis was employed to analyse interview texts (Table 7) of two SMEs using Content Analysis. In terms of data collection, out of 68, only two SME participants have fully participated because of their busy executive schedules. However, this study was intended to serve as a preliminary guide for further research in the area of Web technological development and innovation activity.

Using Content Analysis, the above-selected interview texts of the first and second respondents were coded (Table 7; Figs. 4 and 5). The coding indicates it is imperative for SMEs to regularly update Web technology from Web 1.0 to Web 2.0 to Web 3.0. This is because technological development has pressurised and driven the development of the company's marketing-mix innovation activity from price, promotion, process to new product development. It also indicates that more SMEs use Web 2.0 technology since it allows customers to do more than just view static information but also allows for social networking, blogging, videosharing, Web applications, folksonomies, user-created Web sites, tagging, social bookmarking and other aspects.

Furthermore, social networking and blogging have served as Marketing Intelligence Systems (MkIS) by providing feedback to SMEs on aspects pertaining to market demand, competition and feedback on new products. Past research (Krishnan and Saldanha 2010; Patrick and Dotsika 2007) also supports the finding that nowadays more companies employ social networking to enhance their innovativeness, product specification and service delivery.

Although the word 'innovation' was not directly stated by interview participants, it is implicit in the interview texts which imply Web technological development has driven innovation activity levels in the company by enhancing incrementally services that both support the product (SSP) as well as services that support the customer (SSC). Although, past research (Mathieu 2001) indicates that SSP does not lead to competitive advantage, this finding does not seem in line with the literature since the application of SSP maintains SMEs' competitiveness, which leads to increase sales. In addition, with increased SSP, SSC and connectivity to the Web, customers are able to research products, compare competitors and find where to get the best service at a competitive price.

Despite this, some SMEs are still using simple Web 1.0 technology to establish their presence online. From Table 8, it is also evident that recently more SMEs have employed Web 2.0 technology by promoting their commercial presence on the internet more dynamically. This finding is in agreement with earlier research (among others, Krishnan and Saldanha 2010; Patrick and Dotsika 2007).

The finding that an increase in the company's Web technological development corresponds to an increase in the company innovation levels is in line with the findings given in the literature. However, it seems that the technology does not exert any impact on other organisational innovation; the association was not significant and was not reported.

Table 7 Selected interview texts

(First respondent, classification: small enterprise, hotel)

“... Since our company sales rely on a Web presence, regular updates of Web site technology need to be optimized for the latest technology including presence on mobile devices, it is necessary to ensure excellent service and retain customers. Nowadays, more people and potential customers use these devices to access the Web. Hence, it is necessary to build mobile-optimized Web sites to accommodate potential clients. In addition, using the latest blogging technology will allow customers to give feedback, improve service delivery and success when launching new promotional, service and special offers for tourists, older people, students and family ...”

(Second respondent, classification: micro enterprise, Chinese restaurant and takeaway)

“... The Internet is no longer considered a ‘luxurious need’ in business. There doesn’t seem to be any aspect of daily trade which isn’t touched by the internet. Consumers often browse for food and speciality menus and order foods online. I consider Web technology the future of restaurants. In addition, both existing and new customers no longer use yellow pages; instead, they use Google and the Web to find local restaurants. Customers are just as inclined to log on to a company’s Web site as go in their cars and drive to a shopping centre. Unfortunately, nowadays customers are able to research foods, compare competitors and find where to get the best service. Hence, we have also provided speciality menus such as Chinese halal foods for Jews and Muslim customers and offer long-term service and more competitive prices in this highly competitive environment, otherwise customers will go to other restaurants ...”

Fig. 4 Coding interview texts (first and second respondents)

Although these correlation coefficients are useful to show the degree of association between variables, the literature (Bryman 2012) indicates that the coefficient of determination (r^2) is more meaningful for fully interpreting the association between the SMEs’ Web technology and their innovation activity scores. r^2 is defined here as the percent of the variation in the values of innovation activity that can be ‘explained’ by variations in the SMEs’ Web technological development. For example, Table 6 indicates that the coefficient correlation between the SMEs’ Web technological level and product (functional) innovation score was 0.641. Accordingly, the coefficient determination is found to be 41.09 %, which means that 41.09 % of the total variation in the company’s innovation activity can be accounted for by the variation in its Web development. However,

there is a relationship between the technological development and price innovation ($r = 0.45$) and it was statistically significant only at $\alpha = 0.05$. In addition, it can be seen that only 20.25 % of the total variation of the SMEs' price innovation scores can be explained by variation in the company's technological development. In contrast, 79.75 % ($=100 - 20.25$ %) of the levels of the price innovation scores were explained by other variables outside the SMEs' level of Web technology such as market demand, managerial perception and others.

To summarise, Table 6 indicates that the level of SME's Web technology usage is associated positively with Environmental (Product) Innovation Score— Q_{15} ($r = 0.682$), and is then followed by other variables such as Product (Functional) Innovation Score— Q_6 ($r = 0.641$), Product (Aesthetic) Innovation Score ($r = 0.602$), Q_{16} is Environmental (Programme) Innovation Score ($r = 0.540$) and Price Innovation Score ($r = 0.450$). All associations are significant at α equals 1 % with a 99 % confidence level, except Price Innovation Score, which is significant only at a 5 % level. To complement the above correlation analysis, the Logit model is provided below (Table 9) to explore the probabilistic impact of technology on the SMES' level of innovation.

Price Innovation	Functional Product Innovation	Process Innovation
<ul style="list-style-type: none"> • Price Discrimination • Services that support customers (SSC) • Incremental 	<ul style="list-style-type: none"> • New Products (halal foods) • Customized Products • Services that support products (SSP) • Incremental 	<ul style="list-style-type: none"> • Relationship Marketing • Services that support customers (SSC) • Incremental

Fig. 5 Critical dimension: marketing-mix innovation (first and second respondents)

Table 8 SME's participants classified by their Web technology

Web Technology	Frequency	Percent
No Web	4	5.90
Web 1.0	26	38.20
Web 2.0	16	23.50
Web 2.0 and e-commerce	22	32.40
Total	68	100.00

Table 9 Logit model—SPSS (output-dependent variable: innovation activity score, Q_{18})

	<i>B</i>	SE	Wald	<i>df</i>	Sig.
Step 1a					
Q_4 (WebTech)	0.598	0.644	16.275	1	0.000
Q_3 (Scope)	0.523	0.709	4.612	1	0.032
Constant	0.671	0.397	2.862	1	0.091

Use of ‘standard’ Logit models requires the dependent variable (DV) to be binary or dichotomic (classification based upon two opposites), however, the use of Logit models with more than two categories has been common in the literature (Garson 2012). We tried this form of classification, incorporating several Likert scales (using multinomial Logit models) but the results were very poor and were not reported. Possible reasons for the poor results were that the samples were not large enough to accommodate sophisticated multinomial Logit models, so the degree of freedom was lost. Following the results, and although the current DV is measured through five Likert scales, the scales were condensed into two dichotomic scales (scales of agreement and disagreement only). Because of this use of dichotomic scales, only 68 samples were applicable to the data set. In addition, caution should be exercised when analysing the data because the calculation used ordinal data of ‘perceived’ values, while the statistical tests are more robust when analysing ratio data of ‘actual values’. However, the empirical framework which has been employed can be used for undertaking a further study with a larger sample size with ratio data.

Overall results from the Logit model with the company’s overall innovation activity as the dependent variable are presented in Table 9. The results reveal that the variables Q_4 (the SME’s Web technological level) and Q_3 (its orientation or operational scope; whether local, national or international) are significant predictors of overall innovation, with $p < 0.05$ (“Sig.” column in Table 9). In Table 9, the “B” column represents the estimated log odds ratio. The “Sig.” column represents the P value for testing whether the SMEs’ technological levels and operational scope are significantly associated with the level of innovation activity. Several attempts were made to include a possible interacting variable (a joint impact of the variables of technology and scope, but the results were not significant and therefore not reported).

Based on Table 9 (SPSS output), the Logit model can be re-produced as follows:

$$\ln \frac{\pi}{1 - \pi} = 0.671 + 0.598 Q_4 + 0.523 Q_3 \quad (7)$$

$$\text{Logit } (Q_{18}) = 0.671 + 0.598 Q_4 + 0.523 Q_3 \quad (8)$$

Equations 7 and 8 demonstrate that increasing Web technology intensifies the log odds of increasing innovation activity in the SMEs (*ceteris paribus*, controlling for other variables). In addition, being more global also increases the log odds of innovation activity (*ceteris paribus*, controlling for other variables). This may be because when SMEs undertake global operations, they tend to learn new ideas from overseas, driving their level of innovation activity (Freitas et al. 2011). According to the SPSS output of the Logit model (Table 9), the following conclusions can be produced:

- (a) Each increased level of technology leads to a more than half-fold enlargement (0.598) in the odds of innovation activity,
- (b) Being a more global company (compared with being a local company) leads to about a 52 % increase (0.523) in the odds of innovation activity.

Relevant studies (Freitas et al. 2011) show that firms formally and informally rely upon external actors for their innovation processes through collaboration agreements and as sources of knowledge. Contrastingly, relevant literature using macro data reveals that the degree of orientation, whether local or international, did not contribute to the innovation progression (Fagerberg and Srholec 2008a, b). This contrasts with the earlier common hypothesis that more global companies have a higher marginal propensity to innovate (MPI).

Overall, the results of the Logit model are in line with Fagerberg and Srholec (2008a, b). Using aggregated data from 75 countries with different levels of technological development, Fagerberg and Srholec (2008a, b) found a strong correlation between the variables of technological capability, government support, social capital and innovation activity. Their study also suggested the important role played by external variables such as politics, economic, social and cultural factors for developing innovation activity.

Conclusions and directions for further research

This study explores the impacts of a company's technological levels on its innovation activity and estimates the probability of SME technology affecting innovation levels. This research was conducted in North Wales, UK, using a relatively small purposive sample of SMEs (small- and medium-sized enterprises) as a case study. In this paper, technology is narrowly defined as Web technology. In contrast, innovation is not narrowly defined as a product or process innovation as cited in the literature, but is comprehensively defined as a new idea, method, or device used by SMEs. Furthermore, innovation is broken down into marketing-mix innovation, environmental innovation and organisational innovation.

The findings reveal a significant correlation between SME technology (Web technological development) and its environmental innovation (product and energy) and product innovation (functional and aesthetic) scores. This correlation is significant at the 1 % level. A significant association also exists between the company's technological development and its price innovation, although the coefficient is significant at only the 5 % level. Technology does not seem to affect the company's organisational innovation.

A further study is recommended which uses a larger sample size and probabilistic sampling, as sampling error (the degree to which a sample might differ from the population) could then be calculated. These findings could then be generalised to the wider population if the sample was representative of the population. For example, stratified random sampling could be employed to stratify the SMEs into standard classifications based on the number of employees and annual turnover. Since this study uses perceived values (the participants' perception of technology, innovation and other variables), further research should employ actual values. However, this would be a challenge for the researcher since there is no aggregated and uniform data, which may lead to measurement issues.

Appendix 1: Survey questionnaires

SME classification

1. How many staff are employed by your enterprise?

- ☐ 1. Less than 10 employees (micro enterprises) ☐ 2. Between 11 to 50 employees (small enterprises) ☐ 3. Between 51 to 250 (medium-sized enterprises)

2. What is your company's annual turnover?

- ☐ 1. Less than 2 million Euros (micro enterprises) ☐ 2. Between 2 to 10 million Euros (small enterprises) ☐ 3. Between 10 to 50 million Euros (medium-sized enterprises)

3. What is the scope of your enterprise, and in which markets does your enterprise market its products?

- ☐ 1. Local ☐ 2. Regional ☐ 3. National ☐ 4. European ☐ 5. Global

4. During the last three years, what type of Web technology has been used by your enterprise?

- ☐ 1. My enterprise has not used any Web technology or world wide web at all.
☐ 2. Web 1.0 (1st generation): my enterprise has used world wide web for merely publishing the company's information (static content, no interaction with customers)
☐ 3. Web 2.0 (2nd generation): my enterprise has used world wide web for publishing the company's information and as social networking with customers (using Blogs, YouTube, Flickr, RSS etc).
☐ 4. Web 2.0 (2nd generation plus): my enterprise is using world wide web for publishing the company's information and social networking with customers (using Blogs, YouTube, Flickr, RSS etc.) as well as marketing products online (using e-commerce and automation)

5. In what type of business activity does your enterprise operate? What your SIC (Standard Industrial Classification)?

- ☐ 1. Agriculture, Forestry and Fishing ☐ 2. Mining and Quarrying ☐ 3. Manufacturing ☐ 4. Electricity, Gas, Steam and Air Conditioning ☐ 5. Water Supply, Sewerage, Waste Management, Remediation Activity ☐ 6. Construction..☐ 7. Wholesale, Retail Trade, Repair of Motor Vehicle and Motorcycles ☐ 8. Transportation and Storage ☐ 9a. Accommodation ☐ 9b. Food Service Activity ☐ 10. Information and Communication ☐ 11. Financial and Insurance Activities ☐ 12. Real Estate Activities ☐ 13. Professional, Scientific and Technical Activities ☐ 14. Administrative and Support Service Activity ☐ 15. Public Administration, Defence and Compulsory Social Security ☐ 16. Human Health and Social Work Activity ☐ 17a. Arts ☐ 17b. Entertainment and Recreation ☐ 18. Other Activities

Marketing-Mix Innovation (Please tick one only, select from 'Lowest' to 'Highest')

- ☐ 1. Lowest/Least/Minimum ☐ 2. ☐ 3. ☐ 4. ☐ 5. Highest/Fullest/Maximum

6. Product (Functional) Innovation Score. During the last three years, to what extent has your enterprise implemented a new product strategy which has not been used before, such as launching new or significantly improved products?

7. Product (Aesthetic) Innovation Score. During the last three years, to what extent has your enterprise implemented a new packaging strategy which has not been used before, such as creating new and different aesthetic design?

8. Price Innovation Score. During the last three years, to what extent has your enterprise introduced a new pricing strategy which has not been used before, such as discriminating prices according to customer demand, offering discounted schemes, rebates etc?

9. Place Innovation Score. During the last three years, to what extent has your enterprise introduced a new distribution strategy which has not been used before, such as opening regional sales channels, branch offices, exclusive retailing etc?

10. Promotion Innovation Score. During the last three years, to what extent has your enterprise introduced a new promotional strategy which has not been used before, such as using different media advertisement, new PR strategy, inclusive trade exhibitions etc?

11. Process (Internal) Innovation Score During the last three years, to what extent has your enterprise improved internal production systems or manufacturing process to produce products, such as using Lean Manufacturing, Just-In-Time Production etc?

12. Process (External) Innovation Score During the last three years, to what extent has your enterprise improved external distribution methods or logistics, such as new supply chain management etc to deliver goods and services to customers?

13. Physical Evidence Innovation Score During the last three years, to what extent has your enterprise improved 'physical evidence', atmosphere and aesthetics of the facility?

Organisational Innovation (Please tick one only, select from 'Lowest' to 'Highest')

☐ 1. Lowest/Least/Minimum ☐ 2. ☐ 3. ☐ 4. ☐ 5. Highest/Fullest/Maximum

14. Organisational (External) Innovation Score. During the last three years, to what extent has your enterprise implemented a new (external) organisational strategy, such as strategic alliance, outsourcing, merger, franchising etc?

15. Organisational (Internal) Innovation Score During the last three years, to what extent has your enterprise implemented a new (internal) organisational strategy, such as new working practices, teamwork activities and improved operational systems for accounting, purchasing and computing etc?

Environmental Innovation (Please tick one only, select from 'Lowest' to 'Highest')

☐ 1. Lowest/Least/Minimum ☐ 2. ☐ 3. ☐ 4. ☐ 5. Highest/Fullest/Maximum

16. Environmental (Product) Innovation Score During the last three years, to what extent has your enterprise improved products which created environmental benefits, such as reduced energy and decreased CO₂ 'footprint' per unit of outputs etc?

17. Environmental (Energy) Innovation Score During the last three years, to what extent has your enterprise improved production systems which created environmental benefits, such as reduced soil, water, noise and air pollution, recycled waste, water, materials etc?

18. Environmental (Legal) Innovation Score. During the last three years, to what extent has your enterprise implemented environmental programmes in response to government regulation, community's demand, taxes on pollution, best practice etc?

Overall Innovation and Performance Indicators

(Please tick one only, select from 'Lowest' to 'Highest')

☐ 1. Lowest/Least/Minimum ☐ 2. ☐ 3. ☐ 4. ☐ 5. Highest/Fullest/Maximum

19. Overall Innovation Indicator. During the last three years, as a result of Web technology, to what extent has the company improved its overall innovation activity?

20. Overall Performance Indicator. During the last three years, as a result of Web technology, to what extent has the company improved its overall performance?

Appendix 2: Statistical findings

See Tables 10, 11.

Table 10 Cronbach's α , item-total statistics

	Innovation score	Scale mean if item deleted	Scale variance if item deleted	Corrected item-total correlation	Squared multiple correlation	Cronbach's α if item deleted
1	2	3	4	5	6	7
Q ₆	Product functional	24.08	46.79	0.787	0.679	0.748
Q ₇	Product aesthetic	23.23	44.332	0.767	0.648	0.789
Q ₈	Price	23.01	45.443	0.549	0.688	0.799
Q ₉	Place	23.44	52.672	0.408	0.591	0.733
Q ₁₀	Promotion	24.01	46.455	0.487	0.712	0.761
Q ₁₁	Process internal	23.08	47.009	0.669	0.771	0.705
Q ₁₂	Process external	24.14	51.709	0.502	0.619	0.773
Q ₁₃	Physical evidence	23.78	48.135	0.709	0.827	0.785
Q ₁₄	Organisational external	23.89	48.537	0.687	0.735	0.748
Q ₁₅	Organisational internal	23.55	44.664	0.591	0.682	0.785
Q ₁₆	Environmental product	23.43	49.094	0.582	0.662	0.767
Q ₁₇	Environmental energy	24.34	48.441	0.453	0.579	0.739
Q ₁₈	Environmental legal	23.44	44.033	0.112	0.674	0.843
Q ₁₉	Overall innovation	23.62	53.792	0.697	0.779	0.706

Table 11 Granger's causality tests; the most efficient equations

	Coeff.	T Stat	P value
Dependent variable: Web technological development (Q4)			
Intercept	0.609	0.730	0.467
Q _{6t-1}	0.852	4.267	0.001
Q _{4t-1}	0.036	0.215	0.644
Dependent variable: product innovation (Q6)			
Intercept	-0.021	-0.231	0.677
Q _{6t-1}	0.151	0.267	0.634
Q _{4t-1}	0.036	1.953	0.015

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