Measurement model equivalence in web- and paper-based surveys

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ABSTRACT

The aim of this research is to investigate whether web-based and paper-based organisational climate surveys can be regarded as equivalent techniques of data collection. Due to the complex geographical placement of various units of the participating organisation and limited internet access, both paper-based and web-based questionnaires were used. Overall, 1295 employees participated in the survey; of these, 899 used paper questionnaires and 396 used the web-based questionnaire.

Confirmatory factor analysis (CFA) in a Structural Equation Modelling (SEM) framework was used to test the tenability of a series of increasingly restrictive models, using goodness-of-fit tests.

The SurveyTracker software survey package was used for the web survey, and SPSS with LISREL was used for the statistical analysis. Several measurement models were tested; four models showed very good fits for both the web-based and paper-based surveys for fit measures such as RMSEA, NFI, NNFI, PNFI CFI, IFI, RFI and BIC. The four path diagrams also allowed the researcher to investigate the two groups of participants' responses and fit measures across different aspects of the organisation, such as strategic issues (4 dimensions), human resource issues (4 dimensions), operational issues and job satisfaction (5 dimensions), and leadership and transformational issues (7 dimensions).

The results indicate that hypotheses H1 to H3 are all tenable. It can therefore be concluded that the web-based and paper-based surveys can be considered equal with respect to similar factor

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structure, with equal factor loadings and equal variances of the factors and equal covariances between the factors. The results may therefore be combined in a single analysis without compromising measurement validity.

Key words: organisational climate survey, Structural Equation Modelling, web-based surveys, paper-based surveys, measurement model equivalence

Introduction

Over the last few years, there have been several reviews and discussions of the strengths and limitations of web-based surveys compared to the traditional off-line alternatives (Perkins 2004). According to Joubert and Kriek (2009), the use of web-based surveys, also known as online surveys, has increased dramatically since their introduction in educational and psychological assessment. Perkins (2004) adds that web-based surveys include those applicable to library and information science, colleges and universities, secondary school education, personnel and other applied settings and, of course, the general survey and survey research industry. The use of computers and the rapid expansion and use of the internet have opened up significant new opportunities for private and public organisations to survey their employees and customers directly. The growing importance of online surveys is highlighted by Hogg (2003), who notes that in 2002 almost $500 million was spent on online surveys in the USA. According to Inside Research, this figure was expected to reach $960 million in 2004 (Aster 2004).

According to Jackson (in Evans & Mathur 2005), it was projected that by 2006 online surveys would account for one-third of all surveys conducted in the USA. Further into the future, some experts predict that the majority of all survey research will be done online. Dolnicar, Laesser and Matus (2009) also agree that the popularity of online surveys is rising.

A study by Mediamarket Research and Intelligence investigated the use of internet panels for survey research and found that the use of internet panels would continue to grow and that it would be foolhardy to ignore this trend (Bairn, Garlin, Becher & Agreste 2009). This is just another indication of the growing interest in online survey methodology. Moerdyk (2009: 226) also supports the above sentiment regarding computer-based testing in South Africa when he notes: "Advanced technological administration and interpretation of computerised versions of existing tests and other psychological instruments will be a common practice in assessment in the next decades."

One of the key decisions for survey research concerns the method of data collection. In many instances, the method of data collection used in a survey study will depend on:

- The survey population, especially their literacy levels and familiarity with computers
- The cost of conducting the survey and which survey method will be the most cost-effective and reliable
- The complexity of the survey population, for example their geographical location
- The length of time respondents will have to complete and return the survey
- How questionnaires and/or responses will be tracked
- How important confidentiality is
- The size of the sample
- Sponsors' expectations of the outcomes of the survey
- The population size, the required sample size, the confidence levels and the margin of error
- The role and impact of stakeholders such as unions, management teams and consultants on the survey process before and after the survey (Church & Waclawski 2001; Kraut 1996).

According to Church and Waclawski (2002), the current state of data collection in organisational surveys can best be characterised as a mixed bag of single and multiple approaches. It appears, however, that some survey methods are on the rise, while others have a less bright future. Babbie (1998) had already noted that electronic techniques are more efficient than conventional techniques and do not appear to result in a reduction of data quality when he pointed out: "You should expect to see more use of computerised techniques in the future". Drasgow and Schmidt (2002) add to this positive view of web-based assessments in discussing the use of web-based assessments and the very high response rate of 76%. The aim of the paper is therefore to determine whether web-based (online) and paper-based surveys can be regarded as equivalent techniques of data collection.

Mixed survey modes

Contrasting opinions regarding the efficiency of computerised (non-web and web-based) as opposed to conventional paper-and-pencil surveys have been voiced for more than 30 years (Cole, Bedeian & Feild 2006). However, the promise of lowered costs and shortened data collection and feedback cycles has encouraged an increasing number of organisations to adopt computer-based survey modes (Deutskens, De

Ruyter & Wetzels 2006). Mixed-mode surveys have, however, been utilised for many years by companies and research organisations. Table 1 provides an overview of six survey methods and the advantages and disadvantages associated with each.

In many instances, the decision of which survey mode to use is determined by the circumstances or cost implications, the desire for convenience, timelines, the need for higher response rates, the regularity of surveys, and organisation specifics such as a computerised environment (Al-Omiri 2007; Thomas 2004). In many instances, factors other than the available survey modes – such as the geographical location of employees or the extent to which staff work in remote areas without computer access – might dictate the survey mode. Another general problem is that of surveying staff members, such as sales representatives, game rangers, labourers, and staff members working in rural areas, who travel a lot or who do not have access to computers or cell phones.

The issue therefore is not whether mixed mode surveys should be used, but rather how valid, reliable and comparable the data collected through different survey modes are. This was typically the question asked by the organisation where the current study was conducted, as a large number of its employees work in areas without direct computer or postal access. The only alternative was arranged sessions in pre-arranged venues with paper-and-pencil surveys.

Various researchers have, however, questioned the reliability, validity and comparability of data collected through different survey modes. Some of the reservations and concerns in this regard are:

- The need for evidence of measurement equivalence (Cole et al. 2006)
- A lack of evidence of measure invariance weakens conclusions, because findings are open to alternative interpretations (Steenkamp & Baumgartner 1998; Weijters, Schillewaert & Geuens 2008)
- Research on paper-and-pencil and online surveys has been limited and has produced mixed findings (Cole et al. 2006)
- Many researchers have seemingly assumed that paper-and-pencil and web-based surveys exhibit adequate cross-mode equivalence (Van den Berg & Lance 2000)
- Different survey modes often produce different answers to the same questions (Dillman, Phelps, Totora, Swift, Kohrell, Berck & Messer 2009)
- Some researchers found mixed results between response mode missing data. Some researchers found a higher non-response percentage on an employee opinion survey for paper-and-pencil respondents compared with web-based respondents, while other researchers found the opposite (Church 2001; Young, Daum, Robie & Masey 2000)

Table 1: Methods of survey data collection

	Positives	Negatives
1. Paper-and-pen or -pencil response	• Most intuitive survey approach to data collection • Allows great flexibility regarding types of items and scales • Participants work directly on the survey document • Moderate level of confidentiality (concerns regarding handwriting can be an issue) • Easy to change at last minute • Can be completed anywhere, at any time, in any order • Lower risk, fewer uncertainties with technical glitches	• Costly to print in large booklets • Costly to administer via mail • Response burden can be high with long documents • Data processing is costly, complex, time-consuming and more prone to errors due to hand entry or scanning process • May require good writing skills • Appears 'low tech'
2. Optical scan form response	• All data contained on single page or multi-page booklet • Easily faxed; low cost to mail • Ease and speed of data processing • Low-cost data entry • Extremely low error rate • High level of confidentiality when individuals complete in own time and mail themselves • Can be completed anywhere, at any time, in any order	• Response burden higher when using optical scan form • Reduced flexibility in working with multiple types of items and scales on same form • Costly to change at last minute • Printing may take weeks • Test-like appearance
3. Voice or telephone response	• Data collection and processing are immediate • Enhanced error correction at entry if screening methods are employed • Greater flexibility in use of context-sensitive items and responses (branching); options exist for follow-up questions • May be perceived by respondents as more interactive	• Often requires that hard copy of survey be administered electronically or via mail anyway to ease response burden • Reduced flexibility regarding length – maximum of 50 items recommended • Open-ended comments must be voice recorded • Confidentiality may be suspect • Costly to change at last minute • Potential for multiple responses from single individual, unless tracked • Requires significant time for initial set-up • Complex to administer in multiple countries due to phone line quality and access

continued

Table 1 continued

	Positives	Negatives
4. Online intranet- or internet-based website response	• Data collection and processing are fast and immediate • Enhanced error correction at entry if screening methods are employed • Easy to administer on network, and users can log in via laptops or desktops whenever they like • Can be easy to change at last minute • Variety of interactive formats and programming techniques available • Perception of being cutting edge and in alignment with e-business mentality • Quicker analysis of data and feedback • More regular surveys can be conducted • Anonymity can be protected • Fewer human resource services required – less photocopying of instrument, typing, scanning, clearing coding and verification of data	• Response requires a computer or terminal • Requires computer literacy (and familiarity) on part of respondents • Requires network access and connectivity • Confidentiality highly suspect due to nature of ID systems often used • Potential for multiple responses from single individual, unless tracked • Can require significant time for initial set-up and debugging, even with the existing 'engines' • System error, server problems, network traffic or limited bandwidth can crash entire process and frustrate respondents • Less sophisticated systems can be problematic (for example, cutting write-in text off at too few characters; not allowing user to save a partially completed survey to finish later, or to submit a form if incomplete)
5. E-mail response	• Data collection and processing is fast and immediate upon return or reply • Enhanced error correction at entry if templates or executables are used (not in simple reply method) • Easy to generate and send simple e-mails and relatively easy to create templates • Easy to administer on network, and users can respond off-line on laptops or desktops whenever they like • Can be easy to change at last minute • May be perceived as more personal and informal	• Response requires a computer or terminal • Requires computer literacy (and familiarity) on part of respondents • Requires network access and connectivity • Confidentiality highly suspect due to nature of e-mail signatures • Potential for multiple responses from single individual, unless tracked • Server problems and network traffic can frustrate respondents when trying to submit results – may not try more than once • Templates and executables may require familiarity with origin programs
6. Fax-back response	• Data collection and processing are immediate upon return or reply fax • Easy to administer multiple faxes to employees • Easy to reply and fax back • Text or responses are automatically scanned	• Response requires access to a fax machine • Office faxes are often shared, making distribution more questionable • Faxes may be illegible at either end • Quality of reply scanning may be poor, making data questionable or requiring significant cleaning efforts • Amount of data that can be collected is limited to simple fax-page format

Source: Adapted from Church & Waclawski (1998) and Perkins (2004)

- The study by Weijters et al. (2008: 420) concluded that: "the current study shows that cross-mode data may be incomparable without corrective measures".

Smither, Walker and Michael (2004) referred to a number of studies that indicated measurement equivalence for paper- and web-based surveys with identical items. Spera and Moye (2001) used covariance structure modelling to test for measurement equivalence between paper-and-pencil and web-based response modes on an employee attitude survey in five countries. While the results for four of the five countries showed equivalence across survey modes, this was not the case in the fifth country.

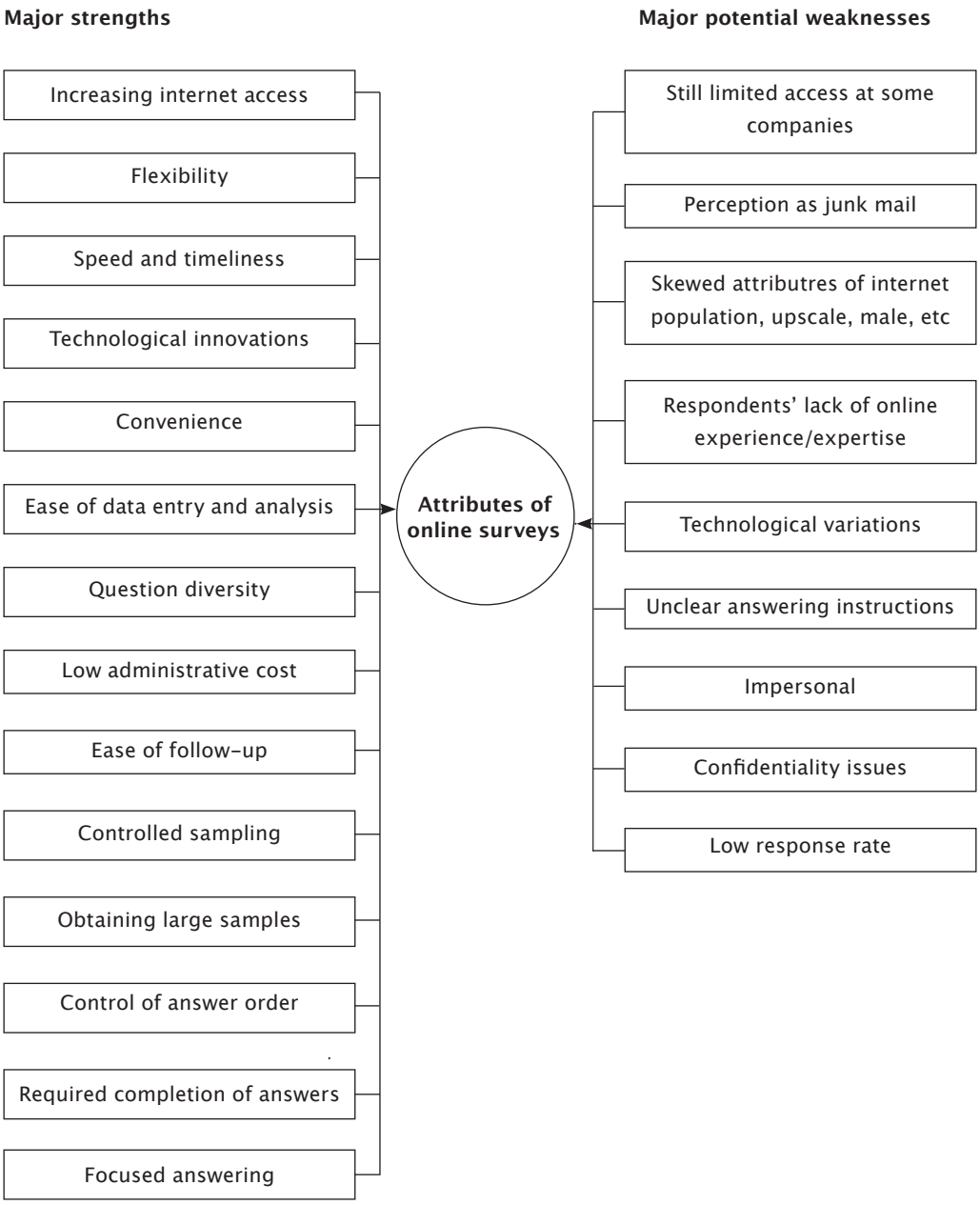
Such reservations and concerns are even more applicable to the South African environment, which is characterised by highly computerised head offices in the main cities, contrasted with a lack of computerised support in rural areas. The use of mixed modes of surveys can thus influence survey results and interpretations. This may lead to incorrect data interpretation, results and recommendations. The aim of this research was to determine whether the paper-based and online versions of the climate survey are invariant in a South African tourism organisation.

Strengths and weaknesses of web-based surveys

Over and above the comparative information in Table 1, the focus of this section will be more on the strengths and weaknesses of web-based surveys as one of the emerging survey modes. The major strengths and weaknesses of online surveys are summarised in Figure 1 and are discussed in more detail in the following sections.

Major strengths of web-based surveys

- *Increasing internet access.* With an increasing number of internet users internationally, the penetration of web-based surveys is increasing every year. The only potential weaknesses for South African users, as well as many international users, are that not all companies allow employees access to the internet, which is a prerequisite for web-based surveys, and not all companies are able to provide their employees with computers.
- *Flexibility.* Online surveys are developed to support a number of different survey distribution formats, such as web surveys (where the survey is placed on the organisation's intra- or internet server) and e-mail surveys (in which the survey is distributed in one of three formats – text-based e-mail, form-based e-mail or HTML-based e-mail) (SurveyTracker 2010). In addition, the questionnaire can



Source: Adapted from Evans and Mathur (2005)

Figure 1: Major strengths and weaknesses of online surveys

easily be tailored to customer demographics such as language, race, gender and organisational division. Drop-down menus with response piping ensure that each respondent sees only the questions pertinent to him/her (Evans & Mathur 2005). The results can then either be analysed on a stand-alone basis or compared with historical surveys in order to help build trend patterns and identify potential problems (Thomas 2004).

- *Speed and timelines.* There is no comparison between the time taken to program a survey, upload it on the software and distribute it to respondents and the traditional process of typing, printing and distributing questionnaires. Typically the distribution phase of a paper survey requires careful planning (Kraut 1996). According to Thomas (2004), the online survey reduces action planning to approximately three days instead of anywhere between six weeks and two months.
- *Technological innovations.* According to Evans and Mathur (2005), online surveys have come a long way from the simple text-based, e-mail surveys of the 1980s to the technologies available today. Some of the typical features of web-based surveys are summarised in Table 2.
- *Convenience.* Online surveys have the flexibility that respondents can answer the questions at any time and in any place as long as they have internet access. Organisations can also dedicate on-site computers for assessment purposes (Drasgow & Schmidt 2002).
- *Ease of data entry and analysis.* It is relatively easy for respondents to complete online surveys. Much of the administrative burden of sending and receiving questionnaires, coding, data capturing and cleaning data is also considerably reduced. Once the last questionnaire has been submitted, the researcher instantaneously has all the data stored in a database (Kraut 1996; Wilson & Laskey 2003). According to Thomas (2004), it is possible to analyse and drill down into the data received from online surveys in numerous ways, which provides greater flexibility.
- *Question diversity.* Online surveys make it possible to have a variety of question and scale types, such as single response, multiple response, yes/no, true/false and write in text (see Table 2 for more examples – Questions/Scale types).
- *Low administration cost.* Survey costs can be divided into two categories, namely preparation and administration costs. With regard to preparation costs, online surveys could, until recently, be costly to construct because of the technological and programming requirements. Today, with the availability of advanced survey software and specialised online questionnaire development firms, preparation costs are much lower and online surveys have become increasingly inexpensive (Evans & Mathur 2005; Kraut 1996). In terms of survey administration, online

Table 2: An overview of some of the main features of SurveyTracker

Management
Survey/report creation wizards
Project import/export
Project start/stop dates
Survey library
Survey style library
Quest on library
Message library
Image library
Survey design features
Wysiwyg interface using CSS
Unlimited pages per survey
Unlimited questions per survey
6 scales per question
300 scale choices per scale
3 columns per page
Customisable survey styles for colours and layout
Header/footer
Page numbers
Images/logos
Spellchecker
Thesaurus
Question/scale types
Single response
Multiple response
Yes/no
True/false
Write-in text (single or multiple line/essay)
Write-in numeric
Write-in date
Fixed sum
Forced ranking
Horizontal numerical
Validation features
Must complete questions
Limit text length (single row)
Enforce fixed sum
Numeric range
Date range
Limit responses using respondent ID
Limit responses using cookies

Survey functionality
Skip/hit
Response piping
Mail merge audience and other data
Percent complete
Audience/respondent list/panel
Unlimited audience list
Up to 200 fields for demographics
Sorting
Filtering
Manual entry of respondents
Import respondents from text file
Import respondents from e-mail address book
Centralised distribution
Multiple distributions per survey
Audience sampling methods
Anonymous distribution
Track respondents with respondent ID
Pilot test survey
Distribute surveys by e-mail, paper, disk, etc.
Place web files on your server
Auto host web survey on SurveyTracker.net
Send web invitations via e-mail
Send reminders for e-mail and web surveys
Mail merge audience info into e-mail
Data collection
Import data from text files
Export response data
Normative data entry
Code written responses
Read electronic response data (e-mail, web, etc)
Reports and analysis
Wysiwyg interface
Web-based real-time results
Simple and advanced data filtering
Time-trending of results
Simple statistics (mean, median, mode, etc)
Advanced statistics (variance, kurtosis, etc)
Create numerous tables and graphs
Export reports to PDF
Export reports for use in Microsoft Office

Source: SurveyTracker (2010)

surveys are automatically placed into the database, and then tabulated and analysed in a coordinated, integrated manner that greatly reduces costs. Because surveys are self-administered and do not require postage or interviews, costs are also kept down (Evans & Mathur 2005). Consumer Reports, for example, is among the research organisations seeking to shift much of the work to the internet. In 2002, its annual survey of products and services went out by regular mail to almost four million subscribers. Paper, printing and postage cost $700 000; the organisation's most expensive survey effort. In 2003, nearly 900 000 people subscribing to the magazine's online edition received the survey by e-mail. Each e-mailed survey cost half of its mail counterpart. Even greater savings are expected in the future with the anticipated drop in programming costs (Jackson 2003).

- *Ease of follow-up.* Given the low cost of sending out reminder e-mails and the simplicity of doing so with online surveys, companies are more likely to send out follow-up reminders to participants. If an audience list of participants is used, personalised follow-ups can be targeted specifically at those who have not yet replied (see Table 2 – Track respondents with respondent ID under centralised distribution).
- *Controlled sampling.* Online survey software packages allow the use of all the various sampling techniques available to the researcher such as complete, cluster, random, stratified and systematic sampling (see Table 2 – Centralised distribution).
- *Obtaining larger samples.* With the newest sophisticated survey software packages, the number of respondents is unlimited, and the cost of running a large sample is no longer influenced by distributing printed paper copies but only by the availability of computer access. Another advantage of using online surveys is that an error message is sent back to the sender of the e-mail, allowing the researcher to select another set of individuals from the list in order to attempt to obtain the sample size that the researcher originally envisaged (Wilson & Laskey 2003).
- *Control of answer order.* Schonlou, Fricker and Elliot (2001) note that with a mail survey, a respondent can flip ahead to see how much must still be completed. Online surveys, by contrast, require the respondent to answer questions in the order intended by the researcher, and prohibit the respondent from looking ahead to later questions. This reduces survey bias but may make an online questionnaire appear to have a seemingly endless number of questions. To avoid this scenario, a graphical progress indicator can be quite informative for respondents (see Table 2 – Survey functionality).
- *Required completion of answers.* Online surveys can be constructed in such a way that the respondent must answer a question before advancing to the next question or completing the survey. This eliminates item non-responses and the necessity of

ignoring answers that have not been entered properly. Studies indicate that online surveys have a much higher item completion rate than mail surveys. Answers to open-ended questions also tend to be longer in online surveys than in mail surveys (Iliewa, Baron & Healley 2002).

- *Focused answering (routing).* Online surveys can be constructed to ensure that respondents answer only the questions that specifically pertain to them, thus tailoring the survey. This eliminates respondent confusion, because complicated skip instructions are not required. In addition, the perceived questionnaire length is reduced by tailoring the survey. Schonlou et al. (2001) state that this means the software program, rather than the respondent, manages the skip patterns. This reduces errors and simplifies the process of completing a survey from the respondent's perspective. As mentioned in Table 2, some of the latest capabilities of online surveys include item-branching (Kraut 1996).

Major potential weaknesses

If not properly handled, online surveys have potential weaknesses. Solutions to the problem areas are discussed in the following paragraphs:

- *Limited access in some companies.* In many South African and international organisations, a sizable proportion of employees do not have computer and/or internet access. The reasons might be cost, or geographical difficulties associated with employees working in remote areas without internet availability or computer literacy. The only solution to this is to use both paper and online surveys.
- *Perception as junk mail.* According to Evans and Mathur (2005), spam (unsolicited junk mail) is a significant problem. In May 2004, Mersega Labs (2004), an internet security firm, found that 692 million out of 909 million scanned e-mail messages (76%) sent to its US customers were screened as spam. According to the latest research, spam averages 78% of all e-mails sent, and both European and US e-mail users showed that despite knowing the risks of opening spam e-mails, 46% of the respondents still opened them, putting their computers at risk (Wikipedia 2010). The only solution is to ensure that participants are informed in advance of the intended survey and then receive an invitation from a trusted source via the company internet.
- *Skewed attributes of internet population*. Until recently, users of the internet and e-mail were not truly representative of the general population in countries around the world (Evans & Mathur 2005). This is also true of many organisations in South Africa. Again, the only solution to this problem is to use multiple survey modes.

- *Respondent lack of online experience/expertise*. Although the internet population in South Africa is increasing rapidly, many employees still lack the familiarity to answer online surveys with ease. Some South African companies solve this problem by having a call centre number available with expert survey consultants who can assist with any queries.
- *Technological variations*. Online surveys are affected by both the type of internet connection and the configuration of the user's computer. Both these factors may cause downtime problems or prevent the respondent from proceeding with the survey. Again, the solution is a call centre to assist respondents when necessary.
- *Unclear answering instructions*. Online surveys are self-administered. If any instructions are unclear, respondents may quickly become frustrated and either delete or exit the survey. It is therefore crucial to pilot test an online survey to ensure that any uncertainties are corrected before the main survey is activated online.
- *Impersonal*. Evans and Mathur (2005) explain that online surveys are similar to mail surveys in the sense that there is no human contact. This is different from a telephone survey where the interviewer can probe for understanding. As with paper surveys, the only solution is to add open-ended questions and to ensure that the survey sufficiently covers the measured concepts.
- *Confidentiality issues*. Many respondents fear that their survey responses may be intercepted by the organisation's computer department. Employees are usually very reluctant to participate in any survey where there are low levels of trust in the organisation. Two typical solutions are to host the survey on an outside consultant's website and to provide each respondent with a secure password or identification number (Drasgow & Schmidt 2002).
- *Low response rate*. Research by Wilson and Laskey (2003) indicated that response rates from e-mail surveys tend to be lower than those in traditional postal surveys. A number of more recent studies on the response rates of online surveys indicate that online surveys usually obtain higher response rates than other survey types (Evans & Mathur 2005). Thomas (2004) found that response rates have increased from 48% to 71% with online surveys. A solution to possible low response rates is to regularly update participating companies on response rates and to send out reminders to the sample group (see Table 2 – Survey functionality).

From the preceding discussion, the following hypotheses are formulated:

H1. There are similar factor structures tenable across a web-based and paper-based survey.

H2. The factor loadings are equal between a web-based and a paper-based survey.

H3. The variances for latent variables and the covariances between the latent variables are equal between a web-based and a paper-based survey.

Research methodology

Research approach

The aim of this research is to determine whether the data collected through a web-based and a paper-based survey conducted in an organisation can be regarded as equivalent from a measurement perspective. In order to test for measurement invariance across these two survey modes, confirmatory factor analysis (CFA) was used to evaluate the tenability of a series of increasingly restrictive models. The SurveyTracker software survey package was used for the web survey (Table 2), and SPSS with LISREL was used for the statistical analysis.

Sampling

An organisational climate study was conducted in a South African tourism organisation whose employees are geographically dispersed across nine of the ten provinces. Due to the complex geographical placement of various units of the organisation and limited internet access, both paper-based and web-based questionnaires were used. Overall, 1295 employees (that is, 40.8% of the organisation's workforce) participated in the survey. Of these, 899 (40.5% response rate) used paper questionnaires, while 396 (41.6% response rate) used the web-based questionnaire. According to the organisation's IT department, only 30% of the organisation's 1295 employees had access to the Web. The comparison of the web-based and paper-and-pencil sample is in line with the organisational employee profile of employees who have access to the Web.

Table 3 indicates a fairly equal distribution of groups according to years of service, while the majority of participants were male (58.8%) and African (57.7%). Most participants were in the 36 to 55 years age groups (57.5%) and were semi-skilled (32.9%).

Measurement instrument

An organisational climate measuring instrument consisting of 12 demographic questions and 85 Likert 5-point scale items was used for the survey. After consultation with the project team, it was proposed that a validated organisational climate measure

Table 3: Frequency distribution of demographic variables

	Web-based sample N = 396		Paper-and-pencil sample N = 899		Overall results N=1295	
					Frequency	Percentage
Years of service						
0–1 years	39	98.0%	170	18.9%	209	16.1%
2–3 years	82	20.7%	118	13.1%	200	15.5%
4–5 years	54	13.6%	80	8.9%	134	10.3%
6–10 years	84	21.2%	97	10.8%	181	14.0%
11–15 years	48	12.2%	133	14.8%	181	14.0%
16–20 years	48	12.2%	161	17.9%	209	16.1%
21 years and longer	37	9.3%	116	12.9%	153	11.8%
No response	4	1.0%	24	2.7%	28	2.2%
Gender						
Male	197	49.7%	565	62.8%	762	58.8%
Female	193	48.7%	296	32.9%	489	37.8%
No response	6	1.6%	38	4.3%	44	3.4%
Race groups						
African	137	34.6%	610	67.9%	747	57.7%
Coloured	63	15.9%	237	26.4%	300	23.2%
Indian	9	2.3%	3	0.3%	12	0.9%
White	178	44.9%	22	2.5%	200	15.4%
Other (non-South African)	1	0.3%	3	0.3%	4	0.3%
No response	8	2.0%	24	2.6%	32	2.5%
Age groups						
Under 25 years	20	5.1%	70	7.8%	90	6.9%
26–35 years	134	33.8%	226	25.1%	360	27.8%
36–45 years	130	32.8%	305	33.9%	435	33.6%
46–55 years	84	21.2%	226	25.1%	310	23.9%
56–60 years	22	5.6%	53	6.0%	75	5.8%
61 years and older	3	0.8%	2	0.2%	5	0.4%
No response	3	0.7%	17	1.9%	20	1.6%
Job level						
Top management	4	1.0%	3	0.3%	7	0.5%
Senior management	32	8.1%	7	0.8%	39	3.0%
Middle management	137	3.4%	10	1.11%	147	11.4%
Skilled	141	35.6%	71	7.8%	212	16.4%
Semi-skilled or operational band	73	18.4%	353	39.3%	426	32.9%
Basic skills	5	1.2%	408	45.4%	413	31.9%
No response	4	1.0%	47	5.2%	51	3.9%

developed by Martins and Von der Ohe (2003) be adapted using the terminology of the organisation. This measure consists of 13 dimensions. The internal consistency of the 13 dimensions varies from 0.867 to 0.923. The items in the questionnaire were reviewed in consultation with the participating organisation to ensure that they met the organisation's needs. The questionnaire items were also reviewed to ensure that they were as clear as possible so that the respondents would understand the online survey correctly.

Data collection

The online survey was pilot tested to identify potential incompatibilities across operating systems and web browsers. After the pilot test, an electronic message was sent from the CEO to all employees with a third party e-mail address. The message invited employees to participate in the survey and also explained the reason and importance of the project. Employees were assured of their anonymity, as the data were submitted and stored on a third party's computer server. Reminders were sent out twice to encourage non-respondents to participate in the survey. The SurveyTracker software package was used for the online survey. See Table 2 for some features of the software.

The paper-and-pencil surveys were administered by means of facilitators. Employees were invited via internal memorandums and their managers to participate in the survey. The reason for and importance of the project were included in these communiqués. The employees were invited to participate in the survey at various locations throughout the country at venues prearranged by the organisation. Facilitators distributed questionnaires and again explained the process and purpose, confirmed anonymity, answered any questions and collected the questionnaires. The collected questionnaires were then handed over to the third party for data capturing.

Data analysis

Several missing values were present across the data set for various items. In order to make maximum use of observations gathered, multiple data imputation using the EM-algorithm in LISREL 8.8 was used to replace missing values. The researcher chose to delete the record when all observations were missing across the scale from questions q13 to q97. This resulted in the retention of 898 cases for the paper-based survey and 396 cases for the web-based survey for inclusion in a Multi-Group Confirmatory Factor Analysis (MGCFA).

Cronbach's alpha was used to evaluate the internal consistency reliability of the data. The reliability assessment was first done per factor and thereafter by factor structures (Figures 2, 3, 4 and 5). On the basis of the item analysis, those items that lowered the estimated reliability were excluded from further analyses. The Cronbach's alpha scores for the factors ranged between 0.667 and 0.941. A suitable criterion for instruments in the early stages of development is a Cronbach's alpha between 0.5 and 0.6, although for established scales it would typically be about 0.7 (Nunnally 1967). Only four of the factors showed Cronbach's alpha reliability coefficients of between 0.6 and 0.7. All factors were thus retained for further analysis.

The methodology followed for the invariance analysis is detailed in Steenkamp and Baumgartner (1998). Their procedure is a set of hierarchical tests, where each subsequent test becomes increasingly restrictive. The first hypothesis to be tested (H1) tests whether similar factor structures are tenable across groups. The second hypothesis (H2) tests whether factor loadings are equal across groups. The third and fourth hypotheses (H3 and H4) are very seldom tenable, since these hypotheses are regarded as overly restrictive. H3 tests whether the variances of the latent variables and the covariances between the latent variables are equal across groups. The fourth hypothesis tests whether equal error variances are tenable, while H5 tests whether intercepts and latent means are equal across groups.

Results

After careful analysis of the descriptive statistics, a multi-group confirmatory factor analysis (MGCFA) was conducted. The advantage of this approach is that a wide variety of hypotheses about group differences and similarities can be tested. This approach is useful for testing the tenability of a series of increasingly restrictive models, using goodness-of-fit tests. If the first hypothesis of similar factor structures across survey modes is tenable, the second hypothesis tests whether the factor loadings are invariant (equal). If this hypothesis is not rejected, the third hypothesis tests whether variances of the latent variables and covariances between the latent variables are invariant (Byrne 1998). When all three of these hypotheses are tenable, it can be concluded that the measurement instrument is invariant (and, by implication, equivalent) across the two survey modes. Hypothesis 4, as already discussed, is generally regarded as overly stringent and, with hypothesis 5, was not further explored in this study.

Several measures of fit are important to consider in a CFA analysis. Apart from the fit measures, it is imperative that the researcher should use his/her substantive knowledge about the theory tested in the model at all times during model specification.

Once the model has converged and parameter solutions are obtained, each estimate should be examined. The magnitude and the signs of the parameters should be as theoretically expected. The standard errors of the parameters and the significance of the estimates should also be evaluated (Raykov & Marcoulides 2000).

After careful investigation of the survey results and the dimensions, it was decided to compile four path diagrams with estimated parameters for (1) strategic issues, (2) HR issues, (3) operational issues and job satisfaction, and (4) leadership and transformation issues.

Strategic issues

A confirmatory factor analysis (CFA) of how employees of the organisation view the Vision and Mission overall, as reflected in items q13 to q16, their perceptions of the Policies and Procedures in place (q31–q35), their perceptions of Communication within the organisation (q50–q53), and their Image of the organisation (q88–q90, q92) was performed. Two questions, namely q30 and q91, were excluded on the basis of low/unsatisfactory item-total correlations. These items lowered the estimated reliability of their respective constructs.

Initially, a single group analysis was done by combining the two data sets after they had been individually imputed. This analysis yielded a reasonably satisfactory model fit with RMSEA = 0.070. It is generally accepted that an RMSEA of 0.05 represents an adequate fit to the data, 0.08 a reasonable fit, and 0.10 a poor fit. These cut-offs should be relaxed in smaller samples (Arbuckle 1996; Bollen 2007). The path model and a summary of the fit measures appear in Figure 2. Subsequently, the hierarchical tests that have been mentioned were applied using the same model. The test results appear in Tables 4 to 6.

Table 4 gives the Chi-square test results, which indicate that none of the models is plausible. However, this test is overly strict in the case of large samples (Brewerton & Millward 2001: 168). This property of the Chi-square statistic has led to the development of alternative measures of model fit. These results are given in Table 5. When all the results presented in Table 5 are considered, hypotheses H1 to H3 are shown to be tenable, which implies that the hypotheses of a similar factor structure, equal factor loadings and equal variances and covariances of latent variables are all plausible. This implies that web-based and paper-based surveys can be regarded as equivalent with respect to the CFA model and data considered for the strategic issues. The group fit measures in Table 6 confirm the findings presented in Table 5.

Table 4: Chi-square based fit indices for invariance tests on measures of 'Strategic issues'

	Degrees of freedom	Minimum fit function Chi-square	Diff Chi-square	Diff df	Prob
H1: Similar factor structure	234	1434.0	246.8[1]	13	0.0000
H2: Equal factor loadings	247	1680.8	31.0[2]	6	0.0000
H3: Variances and covariances of latent variables equal	253	1711.8	277.7[3]	13	0.0000

Table 5: Other fit indices for invariance tests on measures of 'Strategic issues'

Hypothesis	RMSEA	90% CI RMSEA	NFI	NNFI	PNFI	CFI	IFI	RFI	BIC
H1	0.0857	(0.0813 ; 0.0902)	0.904	0.905	0.778	0.919	0.919	0.889	-242.7
H2	0.0935	(0.0892 ; 0.0978)	0.888	0.893	0.806	0.903	0.903	0.877	-89.1
H3	0.0948	(0.0906 ; 0.0990)	0.886	0.894	0.824	0.901	0.901	0.877	-101.1

Notes:

RMSEA = Root Mean Square Error of Approximation; 90 CI RMSEA = 90% confidence interval for RMSEA; NFI = Normed Fit Index; NNFI = Non-Normed Fit Index (Tucker and Lewis); PNFI = Parsimony-Normed Fit Index; CFI = Comparative Fit Index; IFI = Incremental Fit Index; RFI = Relative Fit Index; BIC = Bayesian Information Criteria

Good fit indicated by:

RMSEA <0.5; NFI, NNFI, PNFI, CFI, IFI and RFI >.90 (Arbuckle 1996; Schumacker & Lomax 1996)

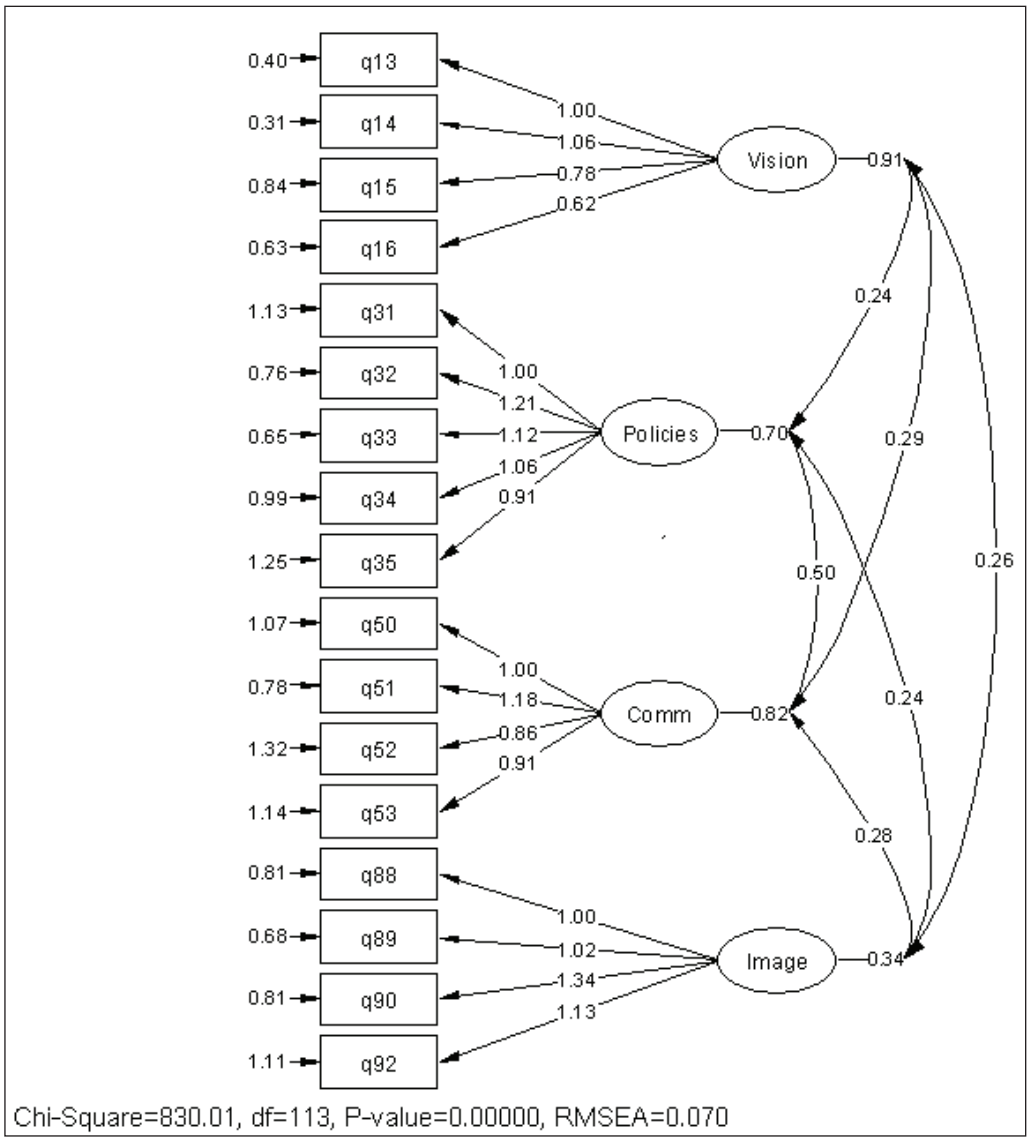
BIC: The smaller/more negative the BIC, the better the model fit (Hu & Bentler 1999)

Table 6: Group fit indices for invariance tests on measures of 'Strategic issues'

	Standardised RMR		Goodness-of-Fit Index (GFI)	
	Paper	Web	Paper	Web
H1	0.088	0.164	0.920	0.819
H2	0.099	0.177	0.902	0.793
H3	0.104	0.160	0.898	0.783

Note:

Good fit indicated by GFI >.90 (Arbuckle 1996; Schumacker & Lomax 1996)



Notes:

- Curved arrow represents correlation between variables
- Arrows pointing towards the observed variable indicate each variable's measurement error
- Latent variables are represented using ovals
- Observable variables are portrayed in rectangles

Figure 2: Single group CFA: Path diagram and estimated parameters for 'Strategic issues'

Human resource issues

The confirmatory factor analysis (CFA) of the human resource issues as viewed by employees of the organisation involved four latent variables, namely; Training and Development (q19–q23), Compensation (q24–q25), Performance Management (q26–q29) and Teamwork (q93–q97). Items q17 and q18 were removed from the analyses due to low item-total correlations in the reliability analysis.

The single group analysis revealed a satisfactory model fit with RMSEA = 0.079, Tucker-and-Lewis NNFI = 0.928 and CFI = 0.941. The results of the single group analysis, which represents the model fitted, are presented in Figure 3. Subsequently, a multi-group CFA was performed. The fit measures are given in Tables 7 to 9.

The results in Table 8 indicate that hypotheses H1 to H3 are all tenable. It can therefore be concluded that the web-based and paper-based surveys can be considered equivalent with respect to all levels of invariance for the human resources issues.

Operational issues and job satisfaction

The confirmatory factor analysis (CFA) of operational issues and job satisfaction as viewed by employees of the organisation involved five latent variables. These variables consisted of Computers (items q37, q38 and q42), Equipment (q39, q40 and q42), Work environment (q46 to q49), Personal job satisfaction (q54–q56) and Job satisfaction of others (q57–q58).

The single group analysis revealed a very satisfactory model fit with RMSEA = 0.059, Tucker-and-Lewis NNFI = 0.965 and CFI = 0.975. The results of the single group analysis, which represents the model fitted, are presented in Figure 4. Subsequently, a multi-group CFA was performed using hierarchical testing. The fit measures are given in Tables 10 to 12.

The results in Table 11 indicate that hypotheses H1 and H2 are plausible models, and H3 is also a tenable hypothesis. It can therefore be concluded that the web-based and paper-based surveys can be considered equivalent with respect to the crucial levels of invariance for the operational issues and job satisfaction.

Leadership and transformation issues

The CFA analysis of leadership, trust, change and transformation issues as expressed by employees of the organisation involved seven latent variables. The latent variables included in the analysis were Trustsup (Trust in direct supervisor, consisting of items q59 and q60), Trustman (Trust in management in general, items q61 and q62),

Table 7: Chi-square based fit indices for invariance tests on measures of 'HR issues'

	Degrees of freedom	Minimum fit function Chi-square	Diff Chi-square	Diff df	Prob
H1: Similar factor structure	200	1078.2	40.0	12	0.0001
H2: Equal factor loadings	212	1118.2	21.2	6	0.0017
H3: Variances and covariances of latent variables equal	218	1139.4	356.7	16	0.0000

Table 8: Other fit indices for invariance tests on measures of 'HR issues'

Hypothesis	RMSEA	90% CI RMSEA	NFI	NNFI	PNFI	CFI	IFI	RFI	BIC
H1	0.0825	(0.0777 ; 0.0873)	0.923	0.924	0.769	0.936	0.937	0.908	-354.9
H2	0.0811	(0.0765 ; 0.0859)	0.920	0.926	0.813	0.934	0.935	0.910	-400.9
H3	0.0805	(0.0759 ; 0.0852)	0.919	0.927	0.835	0.933	0.933	0.911	-422.6

Notes:

RMSEA = Root Mean Square Error of Approximation ; 90 CI RMSEA = 90% confidence interval for RMSEA; NFI = Normed Fit Index; NNFI = Non-Normed Fit Index (Tucker and Lewis); PNFI = Parsimony-Normed Fit Index; CFI = Comparative Fit Index; IFI = Incremental Fit Index; RFI = Relative Fit Index; BIC = Bayesian Information Criteria

Good fit indicated by:

RMSEA <0.5; NFI, NNFI, PNFI, CFI, IFI and RFI >.90 (Arbuckle 1996; Schumacker & Lomax 1996)

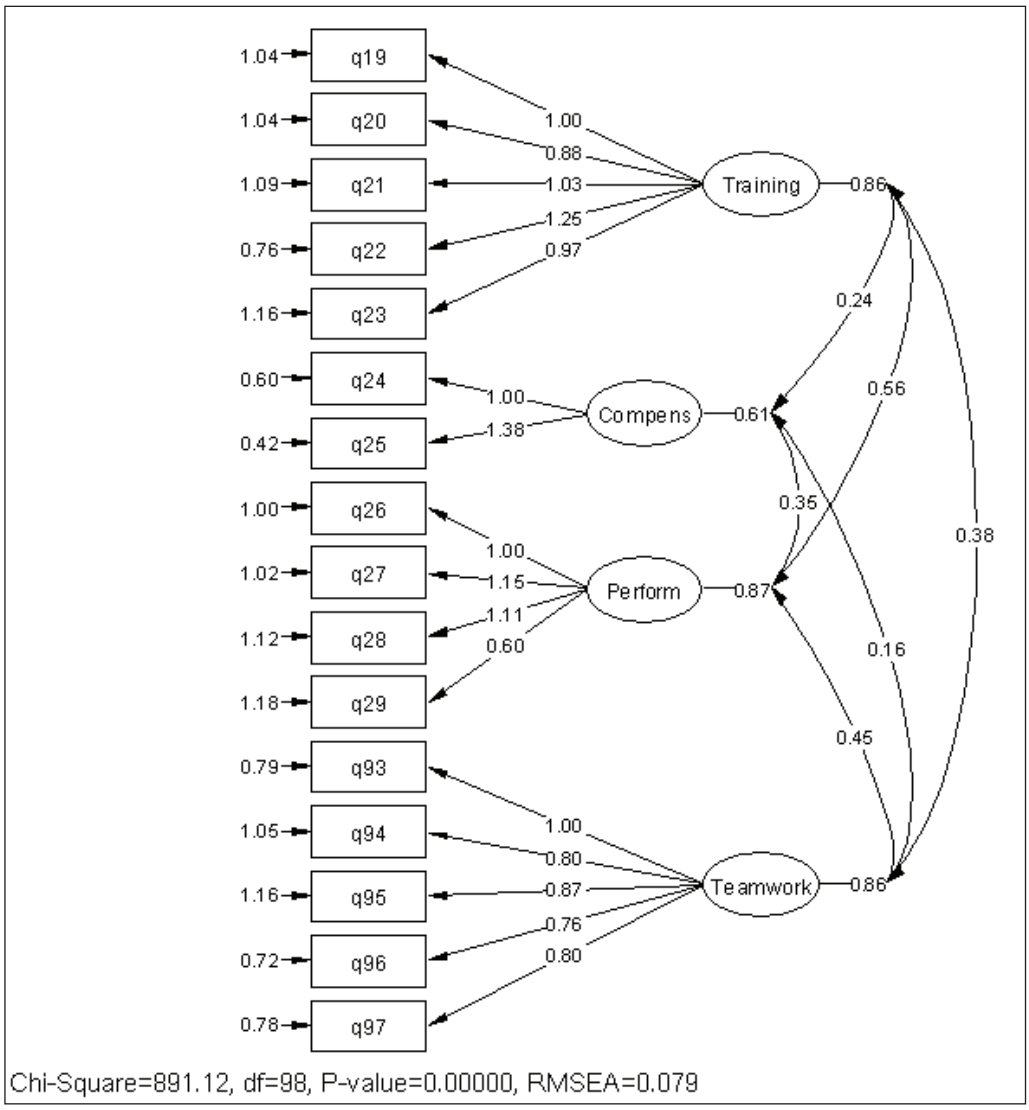
BIC: The smaller/more negative the BIC, the better the model fit (Hu & Bentler 1999)

Table 9: Group fit indices for invariance tests on measures of 'HR issues'

	PAPER	WEB	PAPER	WEB
	Standardised RMR		Goodness-of-fit index (GFI)	
H1	0.065	0.079	0.917	0.881
H2	0.072	0.111	0.915	0.874
H3	0.071	0.097	0.914	0.870

Note:

Good fit indicated by GFI >.90 (Arbuckle 1996; Schumacker & Lomax 1996)



Notes:
- Curved arrow represents correlation between variables
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- Latent variables are represented using ovals
- Observable variables are portrayed in rectangles

Figure 3: Single group CFA: Path diagram and estimated parameters for 'HR issues'

Table 10: Chi-square based fit indices for invariance tests on measures of 'Operational issues and job satisfaction'

	Degrees of freedom	Minimum fit function Chi-square	Diff Chi-square	Diff df	Prob
H1: Similar factor structure	133	508.7	103.7	10	0.0000
H2: Equal factor loadings	143	612.4	46.2	14	0.0000
H3: Variances and covariances of latent variables equal	157	658.6	332.4	14	0.0000

Table 11: Other fit indices for invariance tests on measures of 'Operational issues and job satisfaction'

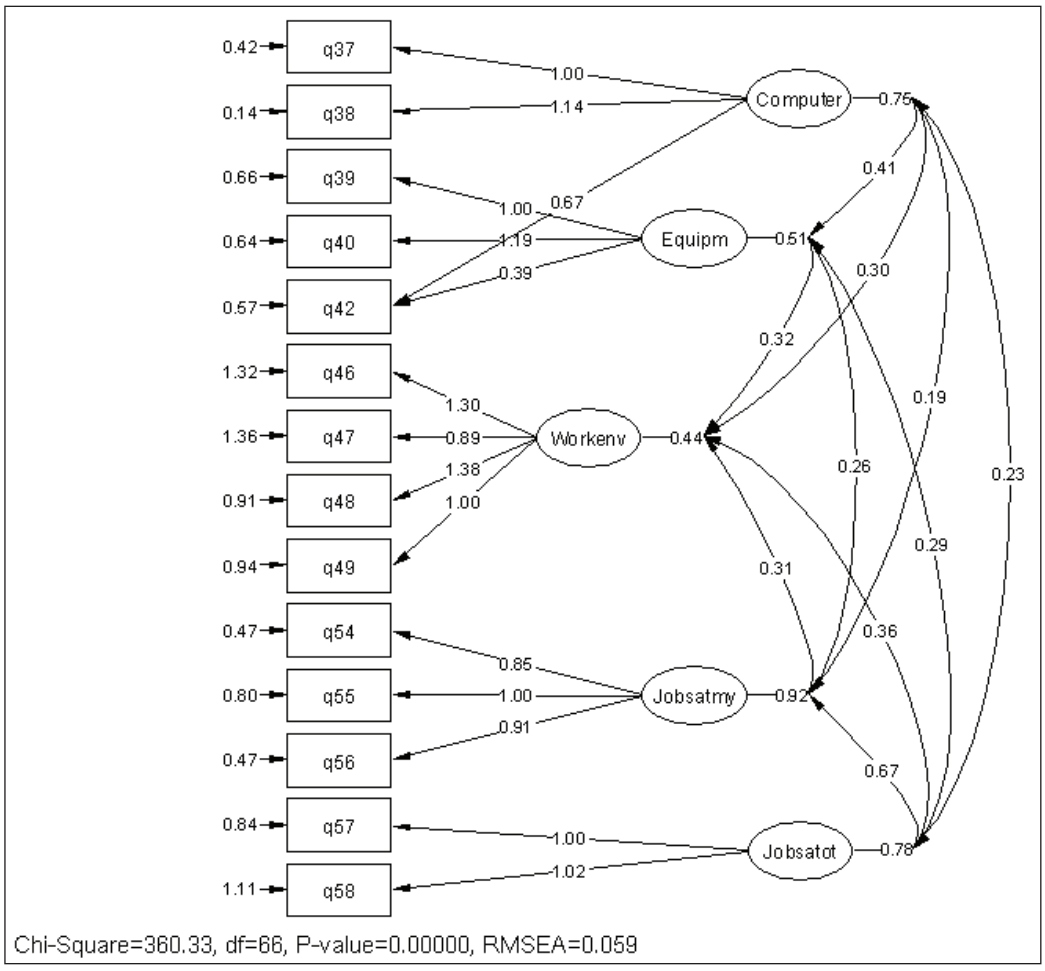
Hypothesis	RMSEA	90% CI RMSEA	NFI	NNFI	PNFI	CFI	IFI	RFI	BIC
H1	0.0661	(0.0601 ; 0.0723)	0.957	0.956	0.700	0.968	0.968	0.941	-444.3
H2	0.0719	(0.0662 ; 0.0778)	0.949	0.949	0.745	0.960	0.960	0.935	-412.3
H3	0.0709	(0.0654 ; 0.0765)	0.945	0.950	0.815	0.957	0.957	0.936	-466.4

Notes:
See notes below Table 8

Table 12: Group fit indices for invariance tests on measures of 'Operational issues and job satisfaction'

	PAPER	WEB	PAPER	WEB
	Standardized RMR		Goodness-of-Fit Index (GFI)	
H1	0.041	0.059	0.961	0.915
H2	0.052	0.086	0.957	0.889
H3	0.061	0.106	0.955	0.877

Note:
Good fit indicated by GFI >.90 (Arbuckle 1996; Schumacker & Lomax 1996)



Notes:
- Curved arrow represents correlation between variables
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Figure 4: Single group CFA: Path diagram and estimated parameters for 'Operational issues and job satisfaction'

Trustemp (Trust in fellow employees, q63–q65), Change management (q66–q70), Leadership (q71–q78), Redequity (Redress and Equity as measured in items q80 and q81) and Transformation (q83–q87). It should be noted that no items were removed due to low item-total correlations, but that new factors or latent variables were formed where required, as in the Trust dimension and in the Redress and Equity dimension.

A single group CFA analysis was performed, and the path diagram is shown in Figure 5. The single group model provided a very good fit with RMSEA = 0.058, the 90 per cent Confidence Interval for RMSEA = (0.0544:0.0612), the Tucker-and-Lewis NNFI = 0.984 and CFI = 0.986. The fit measures appear in Tables 13 to 15.

The results in Table 14 indicate that hypotheses H1 to H3 are all tenable. It can therefore be concluded that the web-based and paper-based surveys can be considered equivalent with respect to similar factor structure, with equal factor loadings and equal variances of the factors and equal covariances between the factors for the leadership and transformational issues.

Discussion

The purpose of this study was to determine whether a measure of organisational climate administered via web-based and paper-based surveys produces data that can be considered equivalent with respect to a similar factor structure, with equal factor loadings and equal variances of the factors. All four of the path diagrams for the four main constructs investigated (strategic issues, HR issues, operational issues and job satisfaction, and leadership and transformation issues) and the subsequent analysis show very good fit. All three of the set hypotheses are therefore accepted.

Compiling the four path diagrams also allowed the researcher to investigate the two groups of participants' responses and fit measures across different aspects of the organisation. The results indicate that all the measured dimensions and items can be combined in a single analysis without compromising validity. With the increased use of computers in the academic environment and in organisations, it appears that more organisations will naturally and increasingly use web-based surveys. The major strengths and weaknesses of web-based surveys are that they need to be used in such a way that the user can ensure that they compensate for potential weaknesses.

This research has shown that the two types of surveys can be considered as equivalent with regard to the factor structure, equal factor loadings and equal variances of the factors in an organisation. Reynolds, Senor, Scott and McClaugh (2000, in Drasgow & Schmidt 2002) came to a similar conclusion. These findings are welcome for researchers, as they provide an empirical justification for using, combining and comparing data from mixed-mode surveys, as researched in this study.

Table 13: Chi-square based fit indices for invariance tests on measures of 'Leadership and transformational issues'

	Degrees of freedom	Minimum fit function Chi-square	Diff Chi-square	Diff df	Prob
H1: Similar factor structure	617	2376.5	49.8	20	0.0002
H2: Equal factor loadings	637	2426.4	125.1	19	0.0000
H3: Variances and covariances of latent variables equal	656	2551.4	1358.9	25	0.0000

Table 14: Other fit indices for invariance tests on measures of 'Leadership and transformational issues'

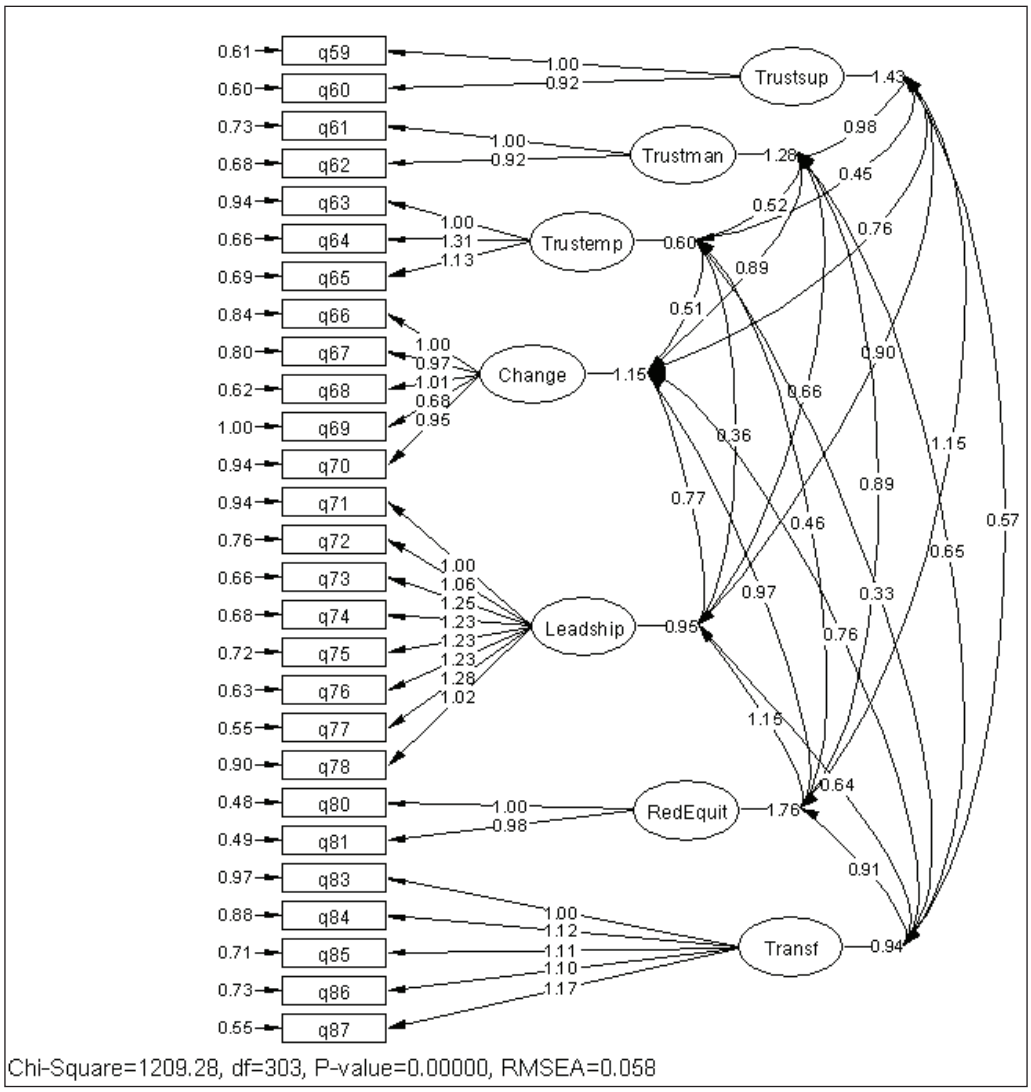
Hypothesis	RMSEA	90% CI RMSEA	NFI	NNFI	PNFI	CFI	IFI	RFI	BIC
H1	0.0698	(0.0670 ; 0.0726)	0.973	0.977	0.855	0.980	0.980	0.970	-2044.6
H2	0.0689	(0.0661 ; 0.0717)	0.973	0.978	0.883	0.980	0.980	0.970	-2138.1
H3	0.0691	(0.0664 ; 0.0719)	0.971	0.977	0.908	0.979	0.979	0.969	-2149.1

Notes:
See notes below Table 8

Table 15: Group fit indices for invariance tests on measures of 'Leadership and transformational issues'

	PAPER	WEB	PAPER	WEB
	Standardized RMR		Goodness-of-Fit Index (GFI)	
H1	0.052	0.115	0.908	0.799
H2	0.055	0.130	0.907	0.797
H3	0.078	0.187	0.904	0.787

Note:
Good fit indicated by GFI >.90 (Arbuckle 1996; Schumacker & Lomax 1996)



Notes:
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Figure 5: Single group CFA: Path diagram and estimated parameters for 'Leadership and transformational issues'

Online research is not the same as off-line research, and the decision about which approach or combination of approaches to use will depend on the availability of respondent samples, the environment, the technological progressiveness of the organisation, and the strengths and weaknesses of each approach. Wilson and Laskey (2003) correctly found in a study comparing the usage of alternative and traditional research methods that 91% of respondents agreed that they would use online surveys as one part of a portfolio of research offerings. This appears to be the way forward for South African organisations; however, where human resources are not computer literate, non-electronic surveys will still be necessary in the near future (Perkins 2004). An important finding of this research is that there were no differences between the four main issues investigated (strategic issues, HR issues, operational issues and job satisfaction, and leadership and transformation issues). This is a clear indication that operational issues as well as strategic issues are not negatively influenced when both approaches are used. Researchers can thus with more certainty include questions on both strategic and operational issues in a measurement of organisational climate.

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