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Back to the Future of Women in Technology: Insights from Understanding the Shortage of Women in Innovation Sectors for Managing Corporate Foresight

Authors:

Vinh Sum Chau* & Chanell Quire

Affiliation:

Kent Business School, University of Kent, Parkwood Road, Canterbury, Kent CT2 7FS, UK.

Email: v.s.chau@kent.ac.uk, Tel: 01227 824404.

Abstract

This paper investigates why there is a shortage of women in innovation, such as science, particularly technology, engineering and mathematics (STEM) sectors and offers insights for managing corporate foresight. It acknowledges that traditional corporate foresight methodologies have their own inherent problems, but argues that greater inclusion of women brings in new dimensions not previously recognised within the predominantly male-dominated technology sector. While extant feminist research may look at the general disadvantages women have in the workplace, few have examined the genesis and constitution of femininity to understand what new input can be brought innovation management, and how these different views can change the conduct of corporate foresight in the technology sector. Interviews from five senior personnel in the technology sector were conducted, and responses to a concise questionnaire involving 365 participants were obtained. Three case-rich narratives are presented as a summary on the future of women in technology.

Keywords: corporate foresight, technology management, women in management, innovation management.

1 Introduction

Improving corporate foresight methodologies for innovation management is part of the bigger picture for how they can be complemented by something that has long been lacking: the female perspective. This paper argues that the technology sector mostly, in which innovation management is key, has suffered a shortage of feminine involvement which constrains technological insights (such as in product development of female-specific products). In a world that is increasingly pushing for greater sex equality and recognition of a market for female specific IT products (eg. mobile phone apps for menstruation, pregnancy, breastfeeding, exercise and vitamin intake, etc), any corporate foresight activity that is limited in this way is likely to forego recognition of the market, as well as traits that women are more prone to having that may be useful in the conduct of corporate foresight exercises.

Hence, this paper goes backwards to examine the root of this problem, to suggest how the difference of women can offer insights for corporate foresight activities in innovation/technology that is not already understood in a male-dominated sector. To understand this, we (i) examine the reasons why many women are not desiring to pursue a career in technology, (ii) explore ways women can be encouraged to pursue technology-related careers, and (iii) identify the key attributes that constitute a woman that can advance innovation management. An inductive stance is adopted for the research that draws from women in technology management, while testing deductively some data collected from technology employment, and presenting case rich discourses on the implications for corporate foresight exercises. The context of the study is the UK, representing western development, rather than a global representation, as numerous such sensitive factors as culture, country employment laws, religion, etc, may otherwise distort the study, and are therefore assumed constant.

2 The Need for Women in Corporate Foresight Exercises

The term 'corporate foresight' is used in this paper as a collective form to mean making meaningful predictions about future opportunities and threats for the organization concerned, although Rohrbeck et al. (2015) explained the evolution of the meaning of 'foresight', and how organizational foresight, managerial foresight, industrial foresight, strategic foresight and corporate foresight differ from each other. Earlier recommendation in the present Journal (van der Duin and den Hartigh, 2009) has included the need of futures researchers to balance the way futures research is done to reflect the innovation and strategy processes of the organization concerned. This means, if the sector is one that is opening up to a particular need or is attentive to an emerging market, the company's associated technological innovation must be both knowledgeable and empathetic of that new market; this in turn requires greater inclusion of women in the methodology of its corporate foresight exercise if that market is specifically women's technological products. A common criticism, for example, is that a

recent Apple Corporation's iPhone health app was entirely based on the functions (and configuration) of men, and was initially launched without involvement, consultation with, or related foresight activities including, women (Lewis, 2014; FT, 2015). This has led to an immediate fall in its mobile phone market to a competitor that was perhaps more comprehensive in its corporate foresight methodology.

Hence, Massari Coelho et al. (2012) has called for more explicit application of foresight into the management plan of organizations and to identify the importance of this in science, technology and innovation sectors as a basis for global sustainable development. Specifically in the UK, recent statistics indicate a gender imbalance within STEM (science, technology, engineering and mathematics) sectors, and the technology sector stands out as being male-dominated (Wise Campaign, 2015). This is concerning, as 72% of UK businesses rely on people with STEM skills while 58% of all new jobs will be STEM related, adding pressure to the need for women to become more involved (STEM Careers, 2015). When new vacancies arise that are described as powerful, challenging and involves high levels of responsibility, they seem to appeal more to men than women; and despite the numerous developments and promotion of gender equality and diversity at work, there has only been around 15% increase in women in STEM occupations and around 35% increase in technology related ones in the recent few years (ibid).

Corporate foresight in innovation management stands out from other contexts (von der Gracht et al., 2010). Ruff's (2015) practical reflections from the automotive industry have included early detection in new business environments and exploration and development in new business areas, among other things, as such key attributes. Sarpong and Maclean (2016) also argue that strategic foresight activities are often generally neglected and its practice would be improved if they took into greater consideration low-level employees, drawing their research also from the technology sector. As women have traditionally suffered barriers to excel to senior positions, any form of increased involvement in foresight activities at lower organizational levels would mean the need to recognise the views of women.

Recent literature has implicitly addressed the issue of impediment within foresight methodology for technology and innovation management. For example, Vecchiato and Robeda (2010) highlight the importance of social drivers of change in the environment, which include events in social, economic, political and ecological landscapes that surround an industry, but do not mention the rise of the importance of women in the new millennium. Battistella and De Toni (2011) also stress the importance of technological foresight requiring a different and specific treatment that relates to the strategic direction of the organization for future orientation, but do not include implications. Similarly, Rohrbeck and Gemunden (2011) argue that corporate foresight that enhances innovation capacity must also serve a strategist role that explores new business fields as well as an initiator role that increases the number of innovation concepts and ideas. Perhaps this may be in the form of

recognising ‘new-wave innovation policies’ that include corrective, disruptive and creative roles (Georghiou and Cassingena Harper, 2011) that encourage breakthrough events and stimulate networks for future sustainability. Currently, only around 25% of IT positions are held by women (Peck, 2015), and only 20% of chief information officer positions in Fortune 250 companies were held by women in 2012 (Khanna, 2013). Hence, this beckons the need to recognise this shortage and its implications for corporate foresight activity in the technology sector.

3 Guiding Hypotheses

As the research traces the origins of the current assumptions held about women in management and their ability to carry out tasks and hold decision making positions, the research explores classical management theories to question their applicability in the technology sector.

3.1 Shortage of women in technology

The gap between women and men holding senior positions is a marked recognition (O’Neill, 2011). For many, the transition from middle to upper management positions is improbable (Eagly, 2003), and those who do are the exception (Molina, 2002). One reason might be because the shortfall itself might lead to the lack of data on how women actually behave in senior positions, creating a vicious circle of there being few in the first place (Cole, 2004).

A classic view of careers development is that known as the Peter Principle (Peter, 1969), which stipulates that employees are appointed to their highest level of incompetence (not competence). The shortage of information, and therefore reduced confidence in women, and fear that incompetence may have far more significant consequences in the technology sector, will imply that women will be appointed to lower levels – ie, to the position of competence, than incompetence. Similarly, it is thought that women are more task-oriented, rather than the traditional stereotypical views of gender roles. In this way, it is hypothesized that: H1 – *a woman’s perception* of the skills needed for a position she has acquired is greater or equal to that of her actual appointed role.

Similarly, society requires women to prove themselves more in employment than their male counterparts (Barsh, 2011), while they blame themselves for any failure (Adams, 2012). They underestimate their skills, abilities and performance, relative to masculine tasks (Beyer, 1998), and take a greater hit on self-confidence when receiving negative feedback than their male counterparts (Roberts and Nolan-Hoeksema, 1989). Public media has also been hostile, as when Facebook’s COO, Sheryl Sandberg, went public The New York Times reported her appointment as being ‘lucky’ than

suggested it as the outcome of her hard work, or in her view, 'having powerful mentors along the way' (Perlroth and Miller, 2012).

Kanter's (1977) theory of Tokenism relates to a woman's negative experience during the job and inability to achieve equality being due to their token status – that is, their low proportion in a male-dominated workplace (Adams, 2012). It is likely that a woman's position in a male-dominated workplace will improve if their proportion is increased, thus improving their token status (Torchia, 2011). This is more easily achieved if their exposure to what may be deemed 'the norm' from an earlier age to women in technology sectors is greater – for example, more role models, etc. Hence, it is hypothesised that: H2 – there is a positive association between the availability of early exposure instruments to women and their subsequent proportion of presence in the technology sector of appointment. The nature of work for women is evidently more difficult, and women need to overwork to overcompensate (Sandberg, 2015). Some work places penalise mothers in professional jobs and affect progression (Glass, 2004), providing evidence of a Glass Ceiling Effect.

3.2 Encouraging women into the technology sector

With the biases in mind, women by college stage are already anticipating the trade-offs between professional and personal goals (Lloyd, 2010). This is worrying, as the academic performance of young girls at college is higher than that of boys, and in the US they earn 57% of the undergraduate and 60% if master's degrees (National Center for Education Statistics, 2014); while in the UK, similarly, women make up 56% of undergraduate degrees (Higher Education Statistics Agency, 2014). This implies that capabilities for achieving high exist, but something else stands in the way, possibly that of willpower, desire, or simply the lack of encouragement.

The early Expectancy Theory of Vroom (1964) stipulates that a person is motivated to select a specific behaviour over others due to the expected result of the selected behaviour, so the motivation is due to the desirability of the outcome (Lunenberg, 2011). For the technology sector, women entering male-dominated industries may be psychologically hindered by anticipation of the unattainable outcome (Pearson, 2012). Hence, it is hypothesised that: H3 – there is a positive association between *women's confidence in the technology sector and the seniority of the position* held. This is influenced by early exposure along the journey, and is based on a role congruity view (Eagly and Diekman, 2005) that discourages take-up of senior positions due to prejudices of less-favourable behaviour by women in the workplace (Karen, 2002). The greater women feel a lack of belongingness from early on, the greater likelihood this will result in reduced entry (Eagly, 2003), and evidence suggests prejudice is highest where inconsistencies in gender roles already are manifest (Wang, 2013). So it is also hypothesised that: H4 – past experience of stereotypical behaviour negatively affects entry into male-dominated industries.

3.3 Constitution of women

The most fundamental of this assumption is the biological make-up of a woman affecting the practical ability to take up a role (Shields, 2003), and different expectations are associated with their gender (Li, 2011). Eagly (2009) identifies a number of emotions relating to women, and the greater the 'emotionally expressive' the more negative impact she will have in the male-oriented workplace, such as in the technology sector. Hence, it is hypothesised that: H5 – there is no association between the biological sex of a person and their attainment of the skills required for employment in the technology sector.

The application of work is affected by social orientation (Barau, 2012), and the most basic of all may be that relating to gender, most strongly affected by nurture, separate from that of biological sex. Differently, gender is the way culture defines and constrains the difference in terms of the male/female dichotomy, so gender and the labels associated with it (feminine and masculine) are neither fixed nor immutable (Siann, 1994). Through social orientation, both genders grow traits and can be learned through situations (Schippers, 2007). While there is not enough research on non-heterosexuals and their working environments (see Johnson and Repta, 2012), the technology sector is still obviously one that nurtures creativity and genders can also be adaptive. So, we hypothesise H6 – there is an association between the gender (non-biological sex) of a person and their attainment of the skills required for employment in the technology sector.

4 Research Methodology

4.1 Data Collection

Data were collected by interviews and via an online questionnaire.

Interviews were employed to obtain in-depth understanding of the experiences women had at various levels of seniority in the technology sector. Purposive and snowball sampling were used, and initial access was successful because the researcher group included an active member of some feminist debate forums via the professional networking website, LinkedIn. It is acknowledged that interviewees solicited from specialist forums may have biased views relating to their forum topic, but this potential bias is balanced out by the need to obtain rich discursion that other less knowledgeable women not from such forums could not offer. The interviews with the five participants were face-to-

face and lasted around an hour, and were digitally recorded and transcribed verbatim to ensure the richness was not lost. The interviewees requested anonymity and are summarized in Table 1.

Table 1: Interviewee Profile

Interviewee	Position held	Years in position	Industry
Ms V	Chief Operating Officer	1	Insurance
Ms W	Director	4	Information Technology and Services
Ms X	Director	5	Medical Devices
Ms Y	Global Head	5	Information Technology and Services
Ms Z	Chairwoman	5	Telecommunications

Using both the themes identified from the interviews, and the extant literature, an online questionnaire obtained responses from targeted technology professional network platforms, both to triangulate in general and to ensure biases would be reduced. The questionnaire link was sent to around 700 invitees and 365 responded. The questionnaire was deliberately simple and based on measures from Bergman and Hallberg (2002), which contained all the questions within one scrollable page, requiring only about five minutes to complete. Measures were mainly in the form of 1-5 Likert scales.

4.2 Data Analysis

Data analysis involved the following.

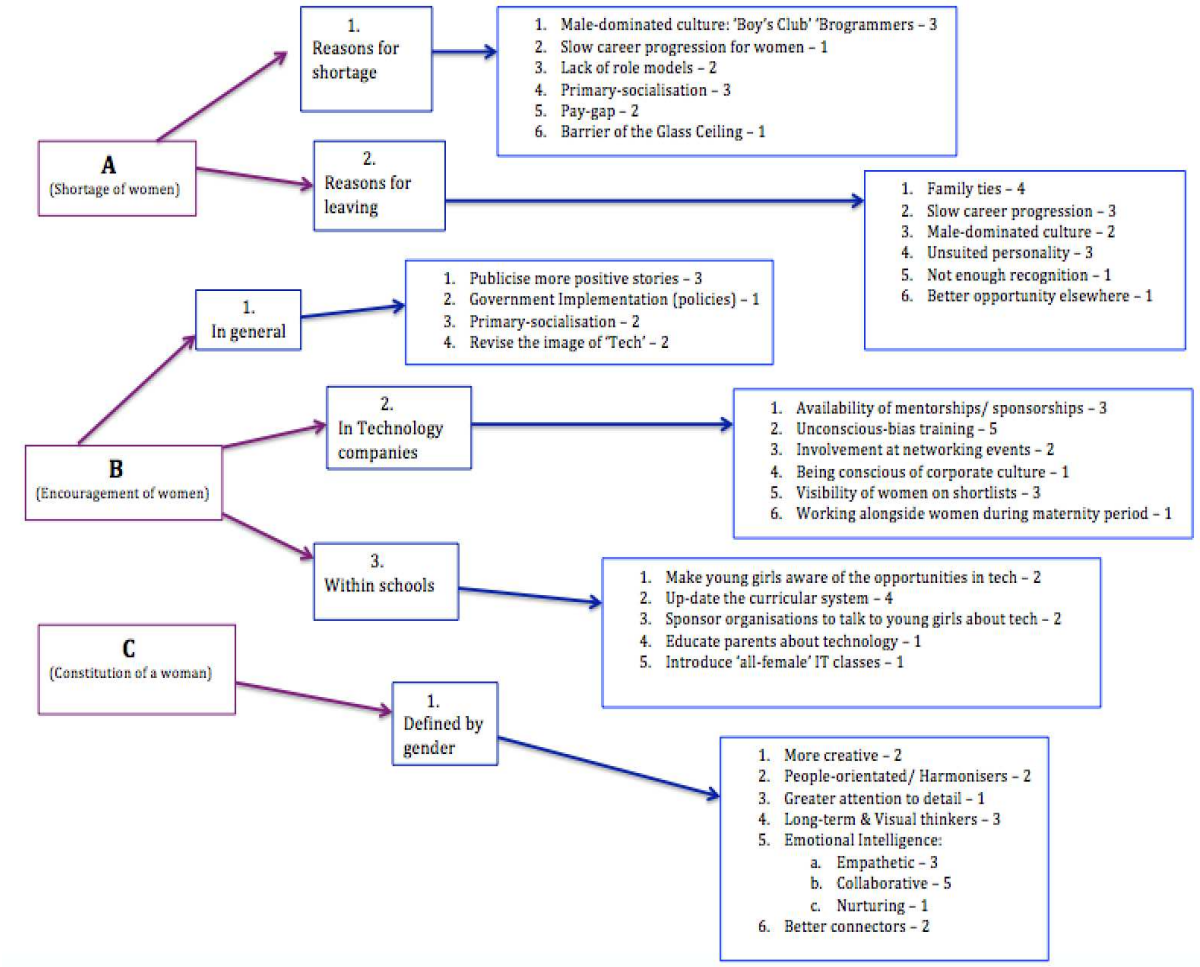
(i) Development of themes: Following Strauss and Corbin (1990), themes from the interviews were obtained through content analysis of the issues discussed. For this, three broad categories were established, using the simple codes of A, B and C respectively. In-vivo coding was used, resulting in a coding tree as given in Figure 1.

(ii) Hypotheses testing: A number of statistical tests were performed to test the specific hypotheses, loosely as a 'hook' for deeper re-examination of the interview material in part III of the research. Hence, given also the reasonably small sample of the data collected, the need for robustness testing was played down, and the results were reported for simplicity of interpretation.

(iii) Case narratives: Drawing on the results of the hypotheses in part II being either rejected or not rejected (supported), explanations for the same were sought from the interview

transcriptions of part I. Broadly within the three themes of the study, supportive commentaries were selected based on dominant themes revealed in the in-vivo coding.

Figure 1: Themes from interviews



5 Findings

5.1 Inductive themes from interviewees

The dominant themes derived from the interviews were used to formulate the questionnaire, and presented in Table 2. The high frequency themes from the inductive interviews as shown in the coding tree above were extracted and formed the basis for the questions in the questionnaire for part II

of the data analysis. These themes were augmented with the extant literature to complete the set of questions to measure specific variables as part of the hypothesis testing.

Table 2: Variables for hypotheses testing

What/Theme from interviews	**Code from coding tree**	**Specific questions in questionnaire**
Male-dominated culture	A.1.1. & A.2.3.	Q11
Lack of role models	A.1.3.	Q14a
Barrier to Glass Ceiling	A.1.6.	Q12
Family ties	A.2.1.	Q7, Q16a
Unsuited personality	A.2.4.	Q15
Publicise positive stories	B.1.1.	Q14
Availability of mentors/sponsors	B.2.1.	Q14
Unconscious bias training	B.2.2.	Q11
Involvement at networking events	B.2.3.	Q14b
Visibility of women on shortlists	B.2.5.	Q14c
Creativity	B.1.1.	Q17b
Emotional Intelligence	B.1.5	Q16c

5.2 Hypotheses testing

The respondents were all in the technology sector, mainly female in biological sex (75.6%), heterosexual (89.4%) and not legally committed to a partnership (68.4%). The sample therefore adequately represents the traditional population of detrimental women in technology as documented in the popular literature.

Table 3: Questionnaire data sample

		N	%
Biological sex	Male	85	24.4
	Female	263	75.6
Chosen gender	Masculine	91	26.1
	Feminine	257	73.6
Sexuality	Heterosexual	311	89.4
	Non-heterosexual	37	10.6
Ethnic background	White	271	77.9
	Non-white	77	22.1
Name	Anglicised	233	67.0
	Non-Anglicised	115	33.0
Marital Status	Married	110	31.6
	Non-married	238	68.4
Have dependants	Yes	97	27.9
	No	251	72.1

The study finds that the response of males and females are quite similar to their belief that they have achieved the skillset needed for their appointment (Male mean = 2.22; Female mean = 2.19), and the difference is statistically insignificant (p=0.771). To test if the hypothesis (H1) stands that the Peter Principle does not apply to the technology sector, both biological sexes' skillset acquired need to be higher (lower in value) (mean = 2.21, SD = 0.871) than post of appointment held (mean = 3.81, SD = 1.203). In this case, the paired mean difference (-1.602) is statistically significant (t=-25.002, df=353, p=0.000), and therefore this part of the hypothesis is not rejected. To cross-check for its applicability for women only, the selected cases (N=269) of women's belief of skills acquired (mean =2.2, SD=0.908) were also greater (lower in value) than post of appointment held (mean = 3.78, SD=1.194), with a paired mean difference (-1.58) that is statistically significant (t=-21.775, df=268, p=0.000). While we acknowledge the potential distortion in the use of self-reported perceptional data in tests relating to the Peter Principle, due to participants' inability to make accurate judgements, together, full support for H1 is nonetheless found.

Table 4: Test of Statistical Differences within Groups of Careers

		Mean	N	SD					
					Paired tests of differences				
Both m/f	Skills set acquired	2.21	354	0.871	Mean	SD	t	df	p
	Post appointment	3.81	354	1.203	-1.602	1.205	-25.002	353	0.000
f only	Skills set acquired	2.2	269	0.908					
	Post appointment	3.78	269	1.194	-1.58	1.19	-21.775	268	0.000
					Independent tests of differences				
Men	Skills set acquired	2.22	85	0.746	Mean difference	F	t	df	p
Women	Skills set acquired	2.19	271	0.911	0.032	2.537	0.291	354	0.771

There is weak support found for H2 that suggests a positive association between early exposure instruments of a woman and the extent of her future employment being technology-focused. Only the presence of role models (mean = 2.98, SD = 1.27) exhibited a statistically significant ($p<0.05$), but reversed ($S\beta=0.137$, $R^2=0.019$), association with the predictor variable. This could be because young women are deterred by the negative experiences and stories portrayed by role models, rather than used them as a positive motivator for entering employment in a more technology-focused sector. Mentors and network contacts do not indicate any predictive power. Hence, there is only partial support found for H2, which otherwise can be rejected entirely (model 3) if all variables are regressed together.

In encouraging women into the technology sector, support for H3 on the association between a woman's confidence and seniority of position held was also only partially found. The characteristic of being a risk-taker was the only statistically significant ($p<0.10$) predictor of the seniority of post held ($S\beta=0.126$, $R^2=0.03$). One reason may be that uncertainty of success in the sector is high and only taking risks is strong enough a motivator for achieving a high-level position. Ambition and boldness are weak predictors. Similarly, only weak partial support is found for H4 on the negative effect of experiencing stereotypical behaviour on entering a male-dominated industry. In this regression model it is clear that suppressor variables existed, which altered the strength of the predictor coefficients depending on the order of how the model was built. In this way, as can be seen in table 3, the stereotype of child-bearing would be highly statistically significant ($S\beta=0.22$, $p<0.01$) without the other complementary predictors, but the predictive power ($R^2=0.048$) is much improved in

the third model (R^2=0.101), where child-bearing is no longer a statistically significant predictor, but the stereotypes of biological sex (Sβ =0.173, p<0.10) and being overly emotional (Sβ =0.138, p<0.10) are. The reason why they cancel each other out might be because of autocorrelation, and such factors as child bearing are naturally related and specific to biological sex.

Table 5: Regression Results

		Mean	**N**	**SD**		**Sβ for Models**		
						1	2	3
H2	Extent tech sector	1.99	350	1.124				
	Role models	2.98	350	1.270		-0.137**	-0.063	-0.061
	Mentors	3.15	350	1.250			-0.098	-0.095
	Network contacts	2.79	350	1.236				-0.009
	Constant					2.346	2.429	2.437
	F					6.627	1.483	0.019
	R-square					0.019	0.023	0.023
H3	Post appointment	3.81	350	1.215				
	Risk-taker	2.55	350	1.022		0.142**	0.177**	0.126*
	Motivated by ambition	1.92	350	0.953			-0.075	-0.095
	Bold	2.32	350	0.984				0.098
	Constant					3.383	3.462	3.384
	F					7.191	1.560	2.031
	R-square					0.020	0.025	0.030
H4	Extent male-dom industry	2.24	354	1.117				
	Child-bearing stereotype	3.10	354	1.470		0.220**	0.083	0.050
	Biological sex stereotype	3.53	354	1.402			0.250**	0.173*
	Overly emotional stereotype	3.36	354	1.449				0.138*
	Constant					1.722	1.343	1.279
	F					17.860	16.915	3.600
	R-square					0.048	0.092	0.101

p values, * = p < 0.10, ** = p < 0.05, *** = p <0.01

As a broad guide for examining the constitution of a woman, H5 and H6 respectively hypothesised the nominal association between biological sex and chosen gender on (the respondents' belief of) achieving the skills specific and necessary for working in the technology sector. H5 is almost fully supported, except for creativity as skill which does have statistically significant association with biological sex (χ^2=3.01, df=1, p=0.083), although the strength of the association is somewhat weak (φ_c = 0.093). This attribute is long believed to be sex-dependent so there might have been some bias in the self-reporting process. H6 however is rejected as the hypothesis that gender does have an association with the belief of achieving the various skills does not hold. The sample included both biological sexes as only a few women (N=6) declared themselves of a different gender orientation from that of their biological sex to select cases to make meaningful statistical inferences.

Table 6: Associations of Nominal Tests

		χ^2 value	df	p	φ_c value
H5	Sex --> Skill, innovative	0.079	1	0.779	0.015
	Sex --> Skill, creative	3.010*	1	0.083	0.093
	Sex --> Skill, problem solve	0.191	1	0.662	0.024
	Sex --> Skill, fast thinking	1.908	1	0.167	0.074
	Sex --> Skill, adaptability/flex	0.012	1	0.914	0.006
	Sex --> Skill, customer focused	0.258	1	0.612	0.027
H6	Gender --> Skill, innovative	0.346	1	0.556	0.032
	Gender --> Skill, creative	0.980	1	0.322	0.053
	Gender --> Skill, problem solve	0.014	1	0.905	0.006
	Gender --> Skill, fast thinking	1.500	1	0.221	0.066
	Gender --> Skill, adaptability/flex	0.003	1	0.954	0.003
	Gender --> Skill, customer focused	0.046	1	0.830	0.012

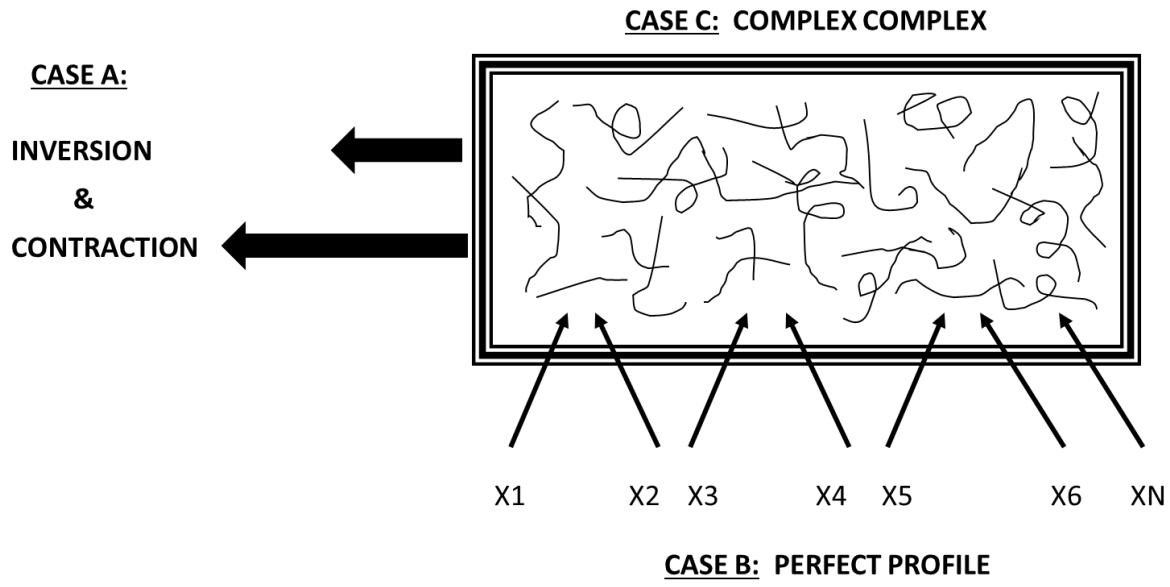
p values, * = p < 0.10, ** = p < 0.05, *** = p <0.01

5.3 Case Narratives

Three themed findings have emerged and are presented in this section as cases A, B and C, and their relationship is given in figure 2. The figure shows that the constitution of women is the 'complex complex' (case C), denoted by a solid box that is difficult to penetrate, but composed of numerous (X1, X2 … Xn of) attributes, conceptualised as the 'perfect profile' (case B), all of which are either

neutral when otherwise positive in non-technology sectors, called ‘inversion’, or suffering serious consequences, called ‘contraction’ (case A).

Figure 2: Relationship of Case Narratives



Case A: Inversion and Contraction

The negativity of role models identified in H2, which seems not to encourage direct entry into the technology sector, but has the opposite effect, and the extent to which childbearing seems a normalised life event for women, can be characterised by the overall phenomenon of ‘inversion and contraction’. This means, there is an inversed expectation that ‘contracts’ the position of women in the sector (notwithstanding the pun of contraction in childbearing!). These biases, not hitherto known, can seriously affect business development in the immediate term and corporate foresight activity in the longer-term future. As an interviewee put it simply: “when trying to get these women into more senior positions it was almost like their careers had stopped” [Ms Z].

‘Inversion’ is when something ordinarily positive seems not to have a positive outcome for the women concerned. The consequences are not necessarily negative, but are neutral when they should under other normal circumstances be deemed celebratory and promotional for the person concerned. Such things should ordinarily improve a person’s professional vitae (resumé) and considered key in building a professional career. An example of being well-networked was commented as follows:

> *"I think that once you hit a particular level in technology, roles aren't adv*ertised to you as much .... *That's why it's important to have a good network ... I think that's the biggest challenge I had faced. I didn't build my network early enough. It's a secret job market."* [Ms Y]

In this situation, Ms Y's attributes had gone beyond internal organizational normal working and received external recognition in being established as part of other professional networks. However, it seems this advantage was not enough to bring forth any benefits for her, and she believed this needed to have materialised even earlier and received greater prominence to be infallible so that others in the workforce could not attack it. The secret job market Ms Y referred to is evidence that the benefit is ignored, and hence illustrates the 'inversion' effect.

Examples of other inversion effects could include having good work ethics, possessing specific qualifications for a wide range of skills, additional vocational activities, or life events like having grown-up children who themselves are well-networked and belong to learned associations. Instead of reaping in-company benefits, these seemed as threats to the male workforce and were therefore brushed off, or subtly ignored. As the judgement of women on the above is most likely different from that of men, the inversion effect is not just a threat to the specific women concern but also to womankind in general if their unique take on corporate foresight is also ignored.

Similar to inversion, but a much more severe form, 'contraction' takes place when the established or normal positivity actually makes the situation worse than before. In the case of Ms V, given as the example below of starting a family, it would seem better not letting others know about it, so that inversion is at least better than contraction:

> *"I just said that it sucked at the thought of having to have a family one day with having my business ... and [a colleague] completely used that against me. He bought all my employees* away from me at double the wage and said that he did that because I am ... *a woman. I've had many challenges about being a woman but that was my worst... It taught me a lot abou*t *how men can twist things ... " [Ms V*]

Had Ms V kept her family planning matters confidential, she would not have suffered the loss of employees that she was in charge of at the time. It is unclear why she was treated in the way she explained as the actions of the man involved seemed completely unrelated to the situation.

While the example given of Ms V might be extreme and singled-out behaviour, contraction is likely in practice to take place more subtly, so that any unfair demotion or detriment goes un-noticed. The trigger points can include a range of life events, skills and attributes like being young and energetic, and even good looks that threaten some men. The detriment could be in the form of reallocation of work responsibilities for more inferior tasks, and a degrading of social status. These actions might at first seem harmless, or at worst rude, but their consequences are long-lasting, if vital market and strategic foresight thinking are lost, which potentially could be important for shaping the future development of the organization.

Inversion and contraction can take place independently, or together. They can happen because of the nature of the social phenomenon, or through the intervention of another actor, mostly that of a male-dominated influence. Other example commentaries of either of these incidences are expanded in Appendix 1.

Case B: Perfect Profile?

Among an array of findings, H1 and H3 seem to characterise the perfect profile of women suited for the technology sector. The name given to this conceptualisation is imperative, as it highlights the importance of 'perfection' and how a simple set of attributes does not suffice for women working in the technology sector; they must possess a substantial set of attributes, and exhibit them well for valuable and recognizable utility. The suggestion that the Peter Principle does not apply to the sector from the hypotheses testing infers a quality of women who are appointed to their worth, and is a risk-taker to have the confidence to work within its difficult environment. Among these wide and general descriptions of women, numerous adjectives were commonly used to express concerns about women in the workplace. The following couple of comments reflect the nature of female behaviour.

> *"[Women] bring a different aspect to the business. They have creativity, different opinions,* they bring about a people-approach *... are more long*-term orientated and are prone to questioning more. They offer a challe*nge ... have a lot more attention*-to-*detail ... and* question whether things are right. They are good harmonisers and so people-*focused ... are visual thinkers. It's e*mpathy *as well." [Ms X*]

> *"Women tend to create environments that are less competitive and more cooperative and collaborative. They tend to be more nurturing ... more concerned with making sure everyone* is moving along in their careers and are happily progressing *... [S]ome have their traits* and *some do not." [Ms Z*]

The narrative of Ms X focuses on qualities that are domain expanding, which are particularly valuable in external environmental scanning in corporate foresight exercises. In the psychology literature, they are associated with right-hemisphere brain activity or typical left-handedness. Our data did not confirm this, as this is not central to the research. However, these are attributes that are few in the general workforce, and are normally associated with historical figures of common knowledge, and less commonly recognised within the male-dominated workforce. Similarly, Ms Z's comment reflects the soft-systems nature of managing human resources. Cooperation, collaboration and humility are team-based skills that are central, not only to ensure good relationships between the male and female members, but also for creating good working environments free from friction and for brainstorming of innovative ideas; in essence, this is the purpose of corporate foresight exercises. These qualities are also empathetic in nature, which ultimately result in better customer service quality and understanding, which again are important antecedents of successful corporate foresight activity.

Indeed, while a few interviewee comments cannot establish an exhaustive list of the ultimate candidacy for appointment within the technology sector, there does seem to be negative consequences for a woman who does not behold 'positive' attributes. This is similar to case A of inversion and contraction, but here the focus is on the various attributes, and hence we argue the quintessential need to possess them as being neutral and not a negative impact per se. In other words, an individual's competitive advantage is not gained if a woman possesses these attributes in the technology sector, and equally their absence does not lead to a loss in individual competitive advantage; however, their unlikely absence might stand out and is a wasted opportunity for an organization.

Ms X comments:

> *"I had an appraisal and I did really well for that year … [and] I genuinely thought I was going to get a promotion … [but] I didn't. The reason was they thought I was 'overweight' and I didn't 'look the part'…* I have the highest performing sales in the company and have maintained that reputation every year, but the excuse for me not getting promoted all that *time was because I apparently didn't have any gravitas." [Ms X*]

Her complaint here focuses on three negative characteristics – being 'overweight', not 'looking the part' and not having 'gravitas'. These characteristics are subjective and often insignificant under ordinary organizational working conditions. However, it seems for women in the technology sector, any characteristics that are (even subjectively) deemed negative would have a detrimental effect on the women concerned, which in other sectors might be treated neutrally.

Other examples of what might have constituted the 'gravitas' are given in Appendix 1. These include: attention to detail, long-term orientation, inquisition, good harmonizers, and people-focused. The restrictive characteristics, indicating frivolity, include: holding back in situations, lacking of confidence, non-self-promoting, and less-competitive. Where women try to take up the restrictive behaviour, they would be seen the negative side of it. As Ms Z describes, "I have experienced being *called 'bossy' rather than being called a 'leader' ... [and] even called 'mean' by another member on* the board". Hence, there are strong and prominent sets of attributes that are apparent, some which are naturally positive but ignored, and some which are neutral or subjectively perceived negative that have detrimental effects. The collective of these attributes that sustain women in technology management thus establishes the case of 'perfect profile'.

Case C: The Complex Complex

In trying to understand what constitutes a woman, which is perhaps the root cause of the shortage problem, it is found that biological sex and gender are only surface level issues. Indeed, there may be more detailed biological and medical explanations for the minutiae of this genetic constitution, but from the management perspective, H5 and H6 identify the woman herself is a complex (noun: a closed system) which itself is extremely complex (adjective: difficult to comprehend extensively), hence being termed a 'complex complex' for women in technology. It (she) is therefore a difficult-to-penetrate closed system that is inherently rich in advice offering. Complexity is used to attribute the complex not simply because issues are too complicated (by this, an intelligent person can still learn the technicalities of the issues) but because they are open to numerous interpretations and advance assimilation, and thus requires a greater degree of empathy.

Interviewees struggled to comment directly on this issue. However, they did talk about women-specific issues, such as menstruation and child-bearing, which are difficult for men to comprehend or empathise with extensively. The reason why these issues constitute part of the complex complex is because, while there are medical experts on these matters, their study is comparatively imprecise as it is based heavily on the psychological aspect as much as the physical composition of the human being. Other examples of the complex noun might include their debatable multi-tasking ability and high EQ psyche. Similarly, examples of the complex adjective might include: ambiguity of body language and interpretation of tones of conversation, differences in choice of vocabulary, and interaction differences, among potentially numerous others.

Sometimes it is not easy to see why women do things, choose to enter a sector or offer up explanations for their approach. In that sense, the basis for that complexity is unexplained altogether. For example, Ms W comments:

> *"I'm not a techy person at all and I've recognised that there are more men in the* engineering, programming side of tech, but if I wanted to do something like that, *I wouldn't let anyone stop me … It's based on your own personal skills, abilities, actions* and *behaviours." [Ms W*]

The above quotation suggests that decisions might be made by impulse, rather than through logical reasoning, but the determination in following through the decision ensures its completion. The value though is that while these impulses are inherently built upon an internal structure that defies logic, they do seem to work, and the ultimate action is socially accepted.

Hence, the complex complex is a phenomenon that is easier to admit its existence than to define its operation. However, its implications for corporate foresight within the technology sector are significant if the complexity is what discourages the inclusion of women in foresight activities. The diversity of interpretation that makes the complex particularly complex is a potential loss if not capitalised, as foresight activities are best operationalized through unusual and multiple dimensions, which gives it a valuable source of competitive advantage for the organization if included.

6 Insights for Managing Corporate Foresight

The above findings offer insightful suggestions for ex-ante corporate foresight activity, and hence also for corporate foresight methodology, specifically within the technology sector. The primary research of this paper did not set out to investigate how exactly such methodology requires changing. However, both the quantitative and qualitative aspects have identified distinctive characteristics about why women are few in the technology sector but are of potential value and could be included more in corporate foresight exercises to reap the benefits they discussed. These suggestions are summarized in Table 7, and discussed as follows.

6.1 Environment, orientation and recruitment

Starting with the extant understanding on corporate foresight and calls for new innovations in methodology (eg. Georghiou and Cassingena Harper, 2011), methodology must move away from a standard external environmental consideration of political, economical, social, technological and legal factors (ie. a standard PESTEL analysis, presented herein as PEcSTEL to differentiate economical from environmental factors) to one that more explicitly recognises the addition of women (W), where

it affects the total of PEcSTEL, plus a smaller constant influence (w). In this way, foresight methodology, F, for the technology context ($_{TECH}$) is:

$$F_{TECH} = f(P, Ec, S, T, E, L, W, w)$$

$$F_{TECH} = W[\alpha + b_1P + b_2Ec + b_3S + b_4T + b_5E + b_6L + \varepsilon] + w$$

The present research indicates this importance of this category and cannot regard it as a variable within either the social or narrow ordinary technological factor (eg. not: P, Ec, S[+W_1], T[+W_2], E, L). In the same way, the orientation of foresight methodology may benefit from incorporating the default prominent anticipation of a growing female future market.

This suggests the need to engage in corporate foresight recruitment panels to involve a disproportion in favour of women in particularly 'controversial cases' where women are found to possess a stronger capability to exhibit attributes of co-operation, harmony and empathy (this is evidenced by Case B from the research). This need is extended to concern if the nature of the industry is itself female-dominated or general, and if so, the panel of predominantly women are best serviced when concerning creative industries (eg. arts and media related technologies), as creativity is also is a predictive attribute from test of H5. The action to do so is not an isolated effort the few leading technology companies that compete for advantage and performance improvement should make, but one concerning global pressure for national governmental bodies to correct stereotypes about women in various careers, particularly STEM ones, at early stages to ensure the unique attributes women possess that are invaluable in sectors requiring innovation can be benefitted from them in both normal strategic, as well as corporate foresight, activities for the sustainable long term future. The use of women and focus on their (perhaps biased) views during market scanning exercises as part of corporate foresight activity have the specific advantage of utilizing a much larger, fast growing and more easily identifiable market of female-related products than other demographic groups (eg. sexual, ethnic and cultural minorities).

6.2 Decision making processes in foresight methodology

The research did identify a difference of expectations of men and women in the technology sector (based on H1) and that women are appointed more to the skillset they possess, despite some potential bias in the sample of respondents surveyed. Entry into STEM sectors may have been affected by the stereotypes experienced in women's early life (based on H2), so the technology sector does have distinctive characteristics, for which some specialist skillsets, such as creativity and risk-taking (based

on H3), can benefit. The suggestions for foresight methodology concern how women are best utilised for decision making and drawing of specific conclusions, as they concern mainly the cognitive reasoning, when otherwise normally relates to one's present and normal past, but for women their past relates more strongly to a personal childhood (H4) which flavours their ultimate decisions. The qualitative research (Case C) also supports this view that while a 'complex' characterises women, it is beneficial to allow 'leaps' in the conclusion drawing process; in this way, it is not always necessary to require clearly articulated derivations for solutions, which might only add further restriction to, and potential compromise of, pushing out frontiers in innovation for the industry whole.

Table 7: Comparison of Existing Methodology and New Implications from the Research

Dimension	**Existing Foresight**	**New Implications**	**Supporting Evidence**
Environment	PESTEL	PEcSTEL+W+w	Generally
Orientation	Future	Future, with anticipation of increased female markets	Generally, & H4
Engagement in foresight	Normal	Increased effort to recruit women in foresight activity	H1, H2
Division of foresight work	All undertake equal foresight activity	Use women (who are mainly high risk-takers) to engage in diversification heavy scenarios	H3
Cognitive reasoning	Relate to present and normal past	Relate deeply to women's past personal childhood	H4
Nature of industry	Involve random panel for foresight	Involve panel of more women if involving creative industries	H5
Decision making process	Perceived equal assessment of all employee opinions	Recognise small skills more to overcome an inherent bias	Case A
Recruitment panel	Involve sex proportions as recruited	Involve women dominant panels in foresight activities involving 'controversial' cases	Case B
Conclusion drawing process	Expect detailed derivation of solutions at all stages	Allow 'leap' in strategizing decision outcomes	Case C
Example	Scenario planning	STEM specific foresight	All

A suggestion is that technology firm corporate foresight strategists should encourage greater inclusion of women in general, and to identify women with more creativity and boldness, in such exercises. The division of foresight work should be separated, so that business and innovation related decisions concerning highly diversified scenarios are undertaken predominantly by women, who are high risk-takers (H3). While this approach might be seen as positive discrimination and working against equality principles, it is likely to be neutralised by the long-term inherent biases against women (Case A), and calls are placed on the further need to recognise small skills that might otherwise be a lost oversight.

7 Conclusion

We end by highlighting the value and promise of the research data, and reiterate the importance of practice to recognise our findings. Our overall research approach was deliberately simple: our guiding hypotheses provided a gauge of the position of the shortage of women in technology, while the case interrogations examined more explicitly the underlying issues that can potentially improve corporate foresight activity. While our data were few in quantity and limited in some self-reporting perceptions, they were nonetheless rich in purposive value. The narrowly targeted sample ensured high respondent participation, but we are bereft of the complex biological, psychological, or even technical differential minutiae of women in management research findings, which are the research's limitation. Without embarrassment or apology, we believe the simple yet strong messages of narration are an important contribution to the extant literature: to make explicit the inclusion of women in corporate foresight activities within the technology sector in the light of the suggestions made. How exactly to use women within corporate foresight exercises and established methodologies is however the subject of further and future research within the field of technology analysis and strategic management!

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Appendix 1: Additional Commentary in support of Case Narratives

	Case A	**Case B**	**Case C**
Phenomenon	Inversion and Contraction	Perfect Profile?	The Complex Complex
Relate to Hs:	H2, H4	H1, H3	H5, H6
Narratives:	I think that once you hit a particular level in technology, roles aren't advertised to you as much can only really get new roles if you wish to, through your networks. That's why it's important to have a good network. If you have those work relationships with the right people, and then those people actually put in a good word for you, you'd get straight onto a shortlist. Also, the amount of people they are allowed to submit to the shortlist is limited, so they don't really want to put anyone on it that may cause risk. And I think that's the biggest challenge I had faced. I didn't build my network early enough. It's a secret job market. – **Ms Y** The career path for women could also put them off. In technology, you've got to be on top of the technology 24/7; it's very fast paced. I think that when women leave the organisation for a year and have children, they miss out a lot on what has been happening with the company. Technology changes within the blink of an eye and it is hard to keep up. By the time they come back, they feel out-dated with the technology and perhaps lose their confidence and get intimidated by their colleagues when they return. Even taking a career break is never seen as a	An example once in my career, when I had a male boss and I had an appraisal and I did really well for that year, I met all my targets and my colleagues were even so pleased with my performance that year, I genuinely thought I was going to get a promotion. Basically I didn't so I raised it. I needed an explanation, at least so I could improve. The reason was they thought I was 'overweight' and I didn't 'look the part'…I have the highest performing sales in the company and have maintained that reputation every year, but the excuse for me not getting promoted all that time was because I apparently didn't have any gravitas…" – **Ms X** They bring a different aspect to the business. They have creativity, different opinions, they bring about a people-approach, and I just think these things can add strength and value to tech…Women are more long-term orientated and are prone to questioning more. They offer a challenge. I think this helps in delivering a more sustainable piece of technology. Women also have a lot more attention to detail I have found, and question whether things are right. They are good harmonisers and where they are so people-	I'm not a techy person at all and I've recognised that there are more men in the engineering, programming side of tech but if I wanted to do something like that I would. I wouldn't let anyone else stop me…Q14: I think it's based on your own personal skills, abilities, actions and behaviours. **– Ms W** Without having a woman's opinion implemented into things, you won't be able to understand the full picture and provide solutions to it. If you apply this to the creation of apps, being women specific, men wouldn't alone be able to create an app directed for women because they don't know everything about a woman – only a woman does. Such as health apps, they offer pools of information but none of them monitor menstruation. A man would never think to monitor menstruation. If women aren't involved in some of these tech solutions that are being changed – one change in tech can change almost every industry – it's that significant! If women aren't involved technology won't be able to provide solutions to everything provided. If you look at things from just one perspective, you get a very narrow solution**. – Ms Y** Their collaboration. Their willingness to not be so directive

	positive in this industry. The technology sector does not like part-time working. It's like a vicious cycle because the industry isn't helping itself move forward and recruit these women in because they are instantly put off of the cultures that have already been set up. – **Ms X** We do need more positive stories, more role models to look up to, and some tech companies are working on that. Tech City UK for example, has a group of 100 people that they profile every year and make sure they have a balance in women. So there are definitely some companies that are working on making sure everyone knows that there are some women working on interesting things. We need to also make sure young girls aren't getting the wrong idea about the sector. And we need to deal with people who have the bad attitudes. – **Ms Z** When I interviewed for this position a while back, they knew I was in my early 30s and information like this, and I just felt like I was being fished for information. Being a part of the interview process many times, I am familiar with certain behaviours and, basically I was explicitly asked: "Are you going to have a child soon?" If so, basically own up now because we don't want you. I've been in companies where males in the interview panel have come out after interviewing women and been like "Hmm… this woman is in her late twenties though…What if she	focused; they look at the person at the end of the technology. They are visual thinkers. It's the empathy aspect as well. – **Ms X** I do find that there are women like me, who give it everything and then are rewarded with a C-Level position. – **Ms V** I joined because a woman was the head of the company and, the board she put together was very balanced as far as gender went. I thought to myself 'the door is open here. Women can make it to the top.' And I certainly felt that. I liked the way that she ran the business and how collaborative the place was. She created a great corporate culture. However, she sadly retired and a man took over her. The culture changed entirely… The message to me was, even though I was a senior woman, you're not going to get anywhere here and the door is shut now. – **Ms V** Women do tend to hold back and not push themselves forward and this just makes things worse. We also need to teach women to be confident, push themselves forward, take risks etc….. Q9: We don't like fuss, we don't like to promote ourselves, we don't boast about what we are doing. Whereas, generally speaking men are easier at doing that. – **Ms Z**	and, create an atmosphere where both genders feel safe and comfortable in putting out new ideas. I feel that this would bring more innovation to tech companies. They will solve problems quicker. Women have a knack for helping people collaborate in creating a trusting atmosphere. You feel an atmosphere change in the room, feeling women around. There is more of a balance. Men can't act like blokes and it just opens up new avenues of discussion**. – Ms V**

	has a kid?" I'm at a certain age now where I feel people do look at your differently. If a man was to go to an interview, I doubt he'd ever be asked, "But, have you got any children?" Both parents care for their children so why is it that one parent faces prejudice!? I just feel that in technology, there is definitely a 'Boy's Club' mentality. My career would have been different if I was a man. I think I would have got better opportunities. I should have had director a year ago. – **Ms X** I made my own business right, so you can't be any higher up the food chain in your own business. There was an Irish guy who came to Prague – I had been in my business for about 6 years and was ready to leave. I never intended to start this business! It was interesting and fun but wasn't going to be my life. Anyway, this guy – because I was young, naïve, trusting and knew everyone in Prague. It is a very small town. I trusted people. He comes along and says, "Oh, I'd really like to hear a lot more about your business. I'm interested in buying it." – I should have gone the whole legal route and made him sign paperwork, but I didn't. I just went and had a drink with him, told him everything, told him too much. Within a week he went to all of my employees and told them all that I was a woman and that I wanted to start a family – I didn't tell him that, I just said that it sucked at the thought of having to have a family one day with having my business. And he completely used that against me. He bought all my employees away from me at	The shortage of women in tech spurred me on. There have been some cases where I have been at tech events and I have been the only woman, but that makes me memorable. There weren't any other women speaking at conferences but that was a good thing for me personally, but not a good thing for women in general. I've worked with women who have tried to use their sexuality to get in rather than their brains and I think I actually tried to help a couple not to do that. I've just been focused on doing my job and doing it well. – **Ms Z** I have experienced being called 'bossy' rather than being called a 'leader'. Once I was even called 'mean' by another member on the board and I was like "no – I just ask questions that need to be answered. I'm sorry if my tone of voice sounds different to your tone of voice but I know that I'm not being mean." So there is definitely this issue with women trying to be heard in the right way. **– Ms Z** The shortage of women in tech has mostly spurred me on but that is probably due to my personality type. **– Ms Y** It's just about being able to speak up louder because chances are you can do it, you're just not always looked at first to give it a shot. It comes down to self-confidence, insurance and knowledge of the industry. **– Ms W**	

	double the wage and said that he did that because I am an American and I am a woman. I've had many challenges about being a woman but that was my worst… It taught me a lot about how men can twist things, not just men, but turning this whole thing into "Oh, she just wants to have babies more than she wants to have a business…" is like- ugh! Who says I couldn't have both!?... No other females had their own business in Prague except a few other American women or European women. Working in the UK corporate world – men would call it 'unconscious bias' but I wouldn't say it was that unconscious – some of the comments made. – **Ms V** The stereotypes have probably, at times, got in the way and tried to hinder my progress but that just made me want to prove them wrong. There have been times where I wouldn't have even be given eye contact, I've missed out on networking opportunities, there are a number of things. That's why I left my previous company and started my own. **– Ms W**	Women tend to create environments that are less competitive and more cooperative and collaborative. They tend to be more nurturing… these are just stereotypically speaking. They are more concerned with making sure everyone is moving along in their careers and are happily progressing. It is difficult to say. I've worked with all sorts of women, some have their traits and some do not. **– Ms Z**	