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Women in the information technology profession: a literature review, synthesis and research agenda

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Gender differences in IT careers appear to be affecting the competitiveness of companies globally. It is posited that given the current labor shortage in the IT industry, it has become more important than ever to reduce sources of leakage in the IT career paths of women. A model of barriers faced by women in the field of information technology is presented. Three distinct career stages of career choices, persistence and advancement are analyzed. At each stage, the effects of social and structural factors which may act as barriers are identified and discussed. Social factors include social expectations, work–family conflict and informal networks, while the structural factors are occupational culture, lack of role models and mentors, demographic composition and institutional structures. A proposed research agenda is offered. It is suggested that these social and structural factors as well as their interactions will result in turnover of women in IT. *European Journal of Information Systems* (2002) **11,** 20–34. DOI: 10.1057/palgrave/ejis/3000417

Introduction

This paper proposes that in response to the two important factors of current labor dynamics in the IT field and gender's influence on technological innovativeness, it is important to promote womens' entry and advancement of women in the IT work force. Given the current labor shortage in the IT industry, turnover and retention issues have come to the forefront (Maitland, 2001). Several popular as well as academic sources point towards a HR shortage in IT (McFarlane, 1990; Pfleeger & Mertz, 1995). Vitalari & Dell (1998) have reported that the cost of filling a vacancy is as high as 120% of the yearly salary for the position. In this environment, 'women may prove to be a key resource of skilled technology workers for international IT markets' (Maitland, 2001, p 9). However, despite a host of efforts to attract and keep women and minorities in computing, their retention and advancement continues to be a significant challenge in computer-related disciplines (Pfleeger & Mertz, 1995). As a result, more and more companies are reassessing practices that may lead to turnover, including those related to balancing family and work life (Goff, 2000). Under these circumstances, it has become more important than ever to identify factors affecting women in IT careers that may act as sources of leakage in the pipeline of IT career paths. Once identified, these barriers can be addressed and appropriate solutions to overcome them can be found.

McFarlane (1990) has argued that since women now account for a very large portion of the workforce and occupy an increasingly important position in the economy, the IT profession needs women in its ranks so that it can really represent those who are carrying out the work. The US Bureau of Census (1993) suggests that higher percentages (48%) of women than men (35%) in the US labor force are computer users. This argument is strengthened by the recent studies on effects of gender that suggest that gender can play an important role in determining technology use (Gefen and Straub, 1997; Venkatesh & Morris, 2000; Venkatesh *et al*, 2000). For instance, Venkatesh *et al*. (2000) found gender differences in individual adoption and sustained usage of technology in the workplace. In their study, men's decisions in this regard were more strongly influenced by their attitude toward using the new technology, while women were more strongly influenced by subjective norm and perceived behavioral control. The findings were robust across income, organization position, education and computer self-efficacy.

Gefen and Straub (1997) have argued that gender effects are themselves largely cultural differences (Coates, 1986; Tannen, 1994). Srite (2000) examined the influence of national culture on technology acceptance behaviors while controlling for gender found both these factors to be influential in explaining technology acceptance.

Many have suggested that proportional presence of women in higher ranks where decision-making takes

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place will go a long away toward making the workplace conducive to womens' needs. However, trade journals and academic research alike have confirmed that women in IT fields are concentrated at the lower and middle levels and are under-represented at the higher levels (Frenkle, 1990; Myers, 1990; Marenghi, 1992; Mulqueen, 1996).

In one of very few academic studies on gender differences in IT careers, Truman and Baroudi (1994) concluded that this field may not be immune to the problems of gender discrimination. They analyzed the data gathered by the Society of Information Management (SIM) and found that women received lower salaries than men even when job level, age, education and work experience were controlled. They also observed that there were a disproportionately high number of men in the managerial ranks. Investigating this issue further, Igbaria and Baroudi (1995) investigated the impact of gender on job performance evaluations, job performance attributions and career advancement prospects. Although they did not find any significant differences in job performance ratings, they reported that women are perceived to have less favorable chances for promotion than men. Igbaria and Baroudi call for further research in this area and state:

> **'... future research should explore the potential barriers to promotability among women who have aspirations to IS upper management and executive careers. We need to look at the reasons for the existence of the barriers and possible ways to overcome them'.** (p 117, emphasis mine)

This paper aims to respond to this call. Though the topic of womens' participation in management has been addressed from a variety of directions, no definitive work has presented a model that explains the role of women in the field of IT in a comprehensive manner. There is a need to understand this role, what the future may hold, and how or if IT differs from other professional endeavors in offering opportunities to women. In this paper, my goal is to identify the social and structural factors that may contribute to the status of women in IT. I propose a life-cycle stage model of factors constraining womens' entry and advancement in the field. The model, when tested, may help explain the pyramid structure of womens' presence in the field of IT. While many of the issues discussed are specific to IT, some are global issues that have resulted from organizational changes occurring in response to two critical forces – slowed economic growth in developed nations and the globalization of most industries and organizations.

State of the profession: women in information technology

Information technology, in this paper, refers to 'support for other people's usage of computer systems' (Denning, 1991). This definition allows the analysis and comparison of a range of computer specialists (Wright, 1997; Denning, 1991).

Most current statistics indicate that women account for only about 25% of technology workers in the European workforce, and about 20% in the United States technology workforce (Maitland, 2001). Additionally, there seems to be a polarization in the type of work which men and women do. Shuttleworth (1992) examined the position of women in the computing industry in the US and the UK, and the impact of new technology on women employed in information handling occupations. She found that the majority of women are employed in routine and specialist work, while men are engaged in analytical and managerial activities. For example, in 1990, 86% of all data-entry clerks were female. They further found that 10% of males and only 3% of the females in the survey had achieved senior managerial positions. Research in the UK and US was consistent. In the US, in 1990, 34% of computer programmers, 33.7% of systems analysts (US Department of Labor, 1975–1990) and only 5% of upper management slots in IT industry are estimated to be occupied by women (Myers, 1990; Benditt, 1992).

Despite predictions to the contrary (Reese, 1990), these percentages have not improved in recent years. In 1996, women occupied 30.8% of computer programmer, and 28.1% of systems analyst (US Department of Labor, 1996) positions. According to the US Department of Labor (1983–1996), the proportion of women in highly technical and analytical positions has practically remained constant for more than a decade (29.6% in 1983 and 30.6% in 1996).

In a survey on information systems (IS) demographics, salaries and job satisfaction reveal that the 'glass ceiling' keeps women in midlevel jobs in the IS department (Bretts, 1993). The survey confirmed the existence of a salary gap by gender. Bretts suggested that the reasons for the salary gap might be both structural and social in nature. The reasons presented include the observation that women did not enter the IS field in large numbers until the early 1980s. Another reason is that some women may pass up the chance to take higher paying jobs because they choose not to relocate. The gender differences in IT careers appear to be affecting the competitiveness of countries globally. Tan and Igbaria (1994) found that in Singapore, salaries vary by gender in many jobs. They suggest that this coupled with the rapid growth of technology and the shortage of IT professionals has had an impact on the country's competitiveness. Tan and Igbaria show that the turnover rate among IT professionals in Singapore is high, particularly among software professionals. Canada is also reporting a severe human resources shortage of people with software skills (Van Brussel, 1998). In Canada, women are said to be under-represented in the IT industry at a rate of

30% among software workers compared to 56% in white-collar jobs in other industries.

In sum, the statistics do not bear out the initial optimism shown regarding womens' participation in the field of IT. Since IT is a relatively young field, it had initially been assumed that impediments to the advancement of women long existent in other fields, such as an established 'old boys' network', a large pool of more qualified and experienced male professionals, the lack of female role models and mentors, and established discriminatory practices, would not present the same barriers to women (Berney, 1988). I argue that these viewpoints do not adequately take into account the variety of structural and social factors that inescapably and inevitably shape womens' careers in IT throughout industry and academia.

A model of factors influencing women's professional careers in IT

In this paper, I propose a stage-model of barriers faced by women that affect their entry and performance in the field. This stage-model draws upon the career development model incorporating a series of stages consistent with those presented by Ragins and Sundstrom (1989). Each stage or transition represents a set of opportunities and obstacles to attaining a powerful position in organizations and builds upon the previous ones. The model in this paper also relies on findings of previous research suggesting that men and women follow different paths to power (Kanter, 1977; Gutek *et al*, 1991). Differences in paths to power for men and women reflect well-documented differences in the factors influencing their development throughout their careers (Ragins & Sundstrom, 1989). This results in the presence of fewer women as they move higher in the hierarchy. As a cautionary note, it is not the goal of this paper to imply that the IT field is more discriminatory than any other field, but simply to propose a testable model of barriers which may exist in the field.

The model examines effects of barriers for women on three separate dependent variables – career choice, career persistence and career advancement in IT careers. These three dependent variables represent the three stages of an IT career. We suggest that several structural and social factors affect womens' careers in IT (Figure 1). It is suggested that each of these barriers can serve as a source of leakage in the pipeline, and make a cumulative contribution to the IT labor shortage. In addition to a presentation of social and structural factors, potential interaction effects of these factors at each stage are proposed. It is suggested that it is not sufficient to examine these factors in isolation from one another, as the IS literature on gender has done so far. In order to develop a rich understanding of IT careers, it is crucial that interactions among these factors be considered.

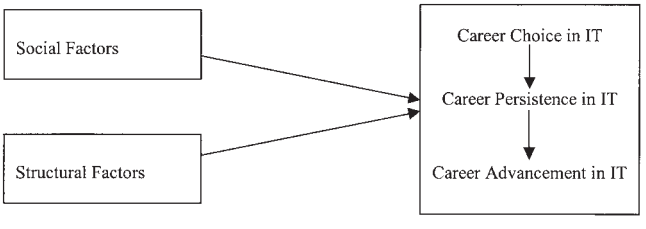

Figure 1 Social and structural determinants of women's careers in IT.

Social factors

These are social and cultural biases that incorporate both the internal view that women have of themselves (self-expectations) and the external view of women (stereotyping, for example) that is held by society in general. For example, Sheinin (1989) and others (Barinaga, 1992; Konrad & Cannings, 1997) have suggested that one factor that explains gender differentials in salary and promotions is the variety of roles that women assume – wife, mother and caretaker – during peak periods of their professional and academic careers. These social factors often result in self-selection into gender-typed professions and positions within professions (Ragins & Sundstrom, 1989).

Structural factors

The notion that the structure of institutions can work to limit opportunities is not a new one (Kanter, 1977; Hennig & Jardin, 1981). Blum *et al* (1994) found that structural factors account for almost half of the variance in the percentage of women managers in organizations. Recent trends in IT towards globalization have also hampered womens' chances of hiring, retention and advancement in positions that require travel and long hours. This is so because women are perceived to be family-oriented and unwilling to travel or work late (Blum & Smith, 1988). In addition, the IT profession requires employees to constantly update their skills, which may translate into long hours. Lack of role models and mentors and the existing proportion of women in the top ranks are examples of structural factors.

Dependent variables

The dependent variables in this model are career choice, persistence and advancement. Career choices are made during university education and entry-level jobs. It is defined as the 'likelihood that a woman will choose IT as a career'. Career persistence becomes an issue when a woman is faced with issues related to starting and raising a family. Operationally, it is defined as 'the likelihood of not dropping out' of the work force. The career advancement stage is comprised of the later years of one's career during which job status and salary become yardsticks of one's overall career performance. Career advancement is the 'likelihood that a woman will

advance in her career in the field of IT'. Figure 2 depicts the model presented in this paper.

It is important to note that that while all of the factors discussed here can influence career choice, persistence, as well as advancement, is more likely to predominantly influence one of these dependent variables. The main social barriers to career choice in IT are social expectations and work–family conflict. The two main structural barriers at this stage are a lack of role models, and the occupational culture existing in computer-related education. Factors affecting the career advancement stage are the social barriers represented by informal networks, and structural barriers represented by lack of mentors and the industry structure of IT.

In the following sections, I will discuss the effects of various structural and social factors and their interaction on womens' career choice and career advancement in the field of IT.

Career choice and persistence

At the career choice stage, women make the critical choices about the field in which they would like to pursue a career. I suggest that social expectations and work–family conflict play important roles in this decision. At the same time, as women are influenced by both educational institutions and industry, structural factors begin to play larger roles in their careers. Shuttleworth (1992) investigated the role of traditional attitudes to women, education and training. She concluded that although women have the potential to take up new opportunities in this field, many of them fail to see IT as an attractive option and are technically ill-equipped to do so.

If a woman finds a way to overcome barriers that may have stopped her from choosing an IT career, she may still find that these factors continue to hamper her persistence in this career. Therefore, issues related to career persistence and advancement are considered intertwined and discussed under the same heading.

Social factors

The social barriers of social expectations and work–family conflict are discussed in the following sections.

Social expectations

Social factors in this context are embedded in cultural values that are, consciously or unconsciously, reflected in behavior. These values in turn play a role in shaping our own values and self-expectations. In ours as well as most other societies, girls and boys are given different signals in a variety of ways throughout their formative

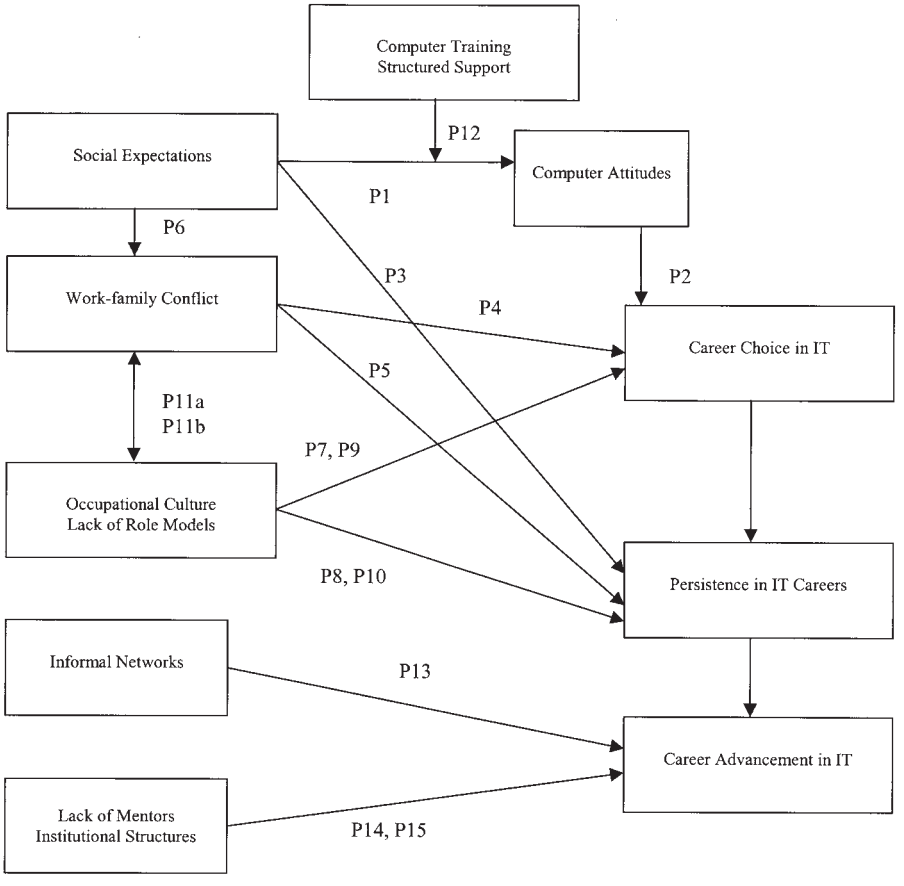

Figure 2 A model of social and structural determinants of women's career choice, persistence and advancement in IT.

years (Kolata, 1984). For example, boys are expected and encouraged to use computers both at home and school (Fetler, 1985; Turkle, 1988). Girls, on the other hand, are less likely than boys to be sent to computer classes and camps (Didio, 1996). Also, girls are steered toward softer subjects like liberal arts and literature, and away from mathematics and sciences. Regardless of the debate on the extent of its effect, the role of social expectations on confidence levels and performance in computer fields (Collis, 1985; Steering Committee on Women in Science, Technology, Trades and Engineering, 1995) is well documented.

As indicated earlier, Gefen and Straub (1997) have argued that gender-related social expectations have roots in national culture. For example, on Hofstede's (Hofstede, 1980) scale of masculinity-*versus*-femininity, certain countries consistently show a masculine tendency. The USA and Switzerland show somewhat masculine tendencies (62 and 70 on a 1 to 100 scale, where 1 is the lowest and 100 is highest) and Japan shows strong masculine tendencies (a score of 95 on the same scale).

It has been suggested by Gefen (2000) that gender-related differences and stereotypes are so strong that many societies have predetermined communication styles that are expected of women and men. Gefen further suggests that these expected communicational styles differ notably among national cultures. These cultures establish gender differences in attitudes regarding computers in grade school (Collis, 1985), and these attitudes widen with age (Smith, 1986). Attitudes towards computers, in turn, have been correlated to achievement in the computer-related classes (Fetler, 1985; Steering Committee on Women in Science, Technology, Trades and Engineering, 1995).

The effect of the social factors discussed above may be evident in the gender differences in adoption and use of computer-mediated communication (Gefen, 2000). In general, studies have reported differences in terms of communication styles, computer conferencing (Stowers, 1995), and the use of internet (for a review of this literature, see Gefen, 2000). Gefen and Straub found that both cross-cultural (national) and gender effects on the perceptions of social presence, usefulness and ease of use, but showed only cross-cultural effects on self-reported e-mail use. Specifically, women were found to feel a stronger sense of social presence than men in the same national culture did, and a stronger perception of the usefulness of the software, but felt the software to be less easy to use than the men did.

Further, significant differences have been shown to exist between electronic communication styles of women and men in that women tend to use electronic communication for rapport building and men for reporting (Gefen, 2000). Stowers (1995), similarly, showed that there was a gender difference in the use of computer conferencing and found that men posted more informational items and women more discussion, personal and support items. Interestingly, training and support reduced gender differences. Much of this literature is in its infancy, and many more studies are required to build a literature base in this area.

Consistent with Gefen's findings, Colley *et al*. (1994) showed that girls and women are less likely to enjoy, use and fully adopt computers and computer tools at all stages of education. Women tend to participate less and are less comfortable with computers than are men (Moldafsky & Kwon, 1994). The role of social expectations in the gender differences in computer abilities has been shown in Collis's (1985) work. Collis found that girls expressed general confidence in female abilities with regard to computers, but did not display the same confidence in their own abilities as individuals displaying a 'we can, but I can't' syndrome.

It is then no surprise that in general, women have been found to display lower computer aptitude (Fetler, 1985), and higher levels of computer anxiety (Morrow *et al*, 1986; Igbaria and Chakrabarti, 1990) compared to men. There is recent evidence from real world settings that women tend to be more anxious than men about computer use (Bozionelos, 1996). A significant body of research in psychology (eg Hunt & Bohlin, 1993) has shown an inverse relationship between computer anxiety and computer self-efficacy, a known determinant of perceived ease of information systems use (Venkatesh & Davis, 1996). Thus, research suggests that higher levels of computer anxiety among women can lead to lower self-efficacy, thus increasing their computer avoidance (Igbaria & Parasuraman, 1989; Venkatesh & Morris, 2000). Anxiety in general has also been found to be negatively related to performance and persistence in the profession (Brod, 1982; Friend, 1982; Humphreys & Revelle, 1984). All these factors may reduce womens' probability of first choosing and then persisting in IT careers.

Based on above discussion, the following propositions are presented:

Proposition 1: Social expectations will negatively influence attitudes towards computers and their use in women.
Proposition 2: Attitudes formed regarding computers and their use will negatively influence the choice of IT as a career in women.
Proposition 3: Social expectations will negatively influence womens' persistence in IT careers.

Work–family conflict

Work–family can be a source of occupational stress. In many IT-related jobs, workers are expected to work late, be on-call to solve technical problems and travel. Work–family conflict has been defined as 'a form of inter-role conflict that occurs when the demands of work and family are mutually incompatible in some respects for

career-oriented men' (Higgins & Duxbury, 1992). Models of work–family conflict suggest that conflict arises when demands of participation in one domain of life are incompatible with demands of participation in another domain and that this conflict can have an important effect on the quality of both work and family life (Greenhaus & Beutell, 1985; Greenhaus 1988; Netemeyer *et al*, 1996).

Research in the 1990s has recognized that the relationship between work and family is bidirectional (Gutek *et al*, 1991; Frone *et al*, 1992), ie family can interfere with work and vice versa. Following this line of thinking, Adams *et al* (1996) attempted to distinguish between family–work conflict (family interfering with work) and work–family conflict (work interfering with family) and developed separate scales for each. They found that family–work conflict may be associated with level of involvement with work. Higher level of work interfering with family predicted lower emotional and instrumental involvement.

Work–family conflict has been negatively linked with several organizational outcomes, including job-satisfaction, organizational commitment and distress on the job (Wiley, 1987; Frone *et al*, 1992; Thomas & Ganster, 1995). Although work–family conflict has not been directly linked with retention, the outcomes discussed above are likely to result in turnover in IT-related jobs. I propose that these outcomes are likely to be negatively associated with choice of IT as a career, performance in computer-related fields and advancement in the field.

Research on work–family conflict has been examined in organizational studies in the context of several different fields (for example, police officers, health care workers, engineers, workers in the construction industry, etc.), but, to date, no research was specifically conducted with IT workers. There is a need for such an examination in the context of IT workers because IT careers, more than most other fields, demand long hours, travel and constant updating of skills. All these factors are likely to lead to work–family conflict for both men and women. However, I propose that because women, who have long focused on family and children, will experience the work–family conflict more than men in the IT industry.

Many womens' early career experiences coincide with the stage in their lives when they are marrying and starting a family. At this stage in their lives, professional women are faced with trying to manage a career, a home and child-care. Additionally, women who have full personal lives may be viewed as lacking a strong commitment to their work or not being as serious about their careers as their male colleagues (Barinaga, 1992). Research suggests that it is at this point that women begin to lag behind men in terms of promotions. Duxbury and Mills (1989) did profile analysis of 359 dual career couples and found that women who put their careers first or on par with their husband's career face more conflict at home than women who put their careers second. Also, men and women who do not use the 'electronic briefcase' (working at home on the computer for work) experience similar levels of work–family conflict while the women who used the 'electronic briefcase' experienced significantly more conflict than the men who did and women who did not.

Research has found that organizational structures do not provide enough flexibility to men and women in dual-career marriages. Higgins and Duxbury (1992) examined differences in the antecedents and consequences of work–family conflict with a homemaker spouse and those with a spouse in a career-oriented job. They found that dual-career men experience a significant spillover from their work domain. The authors suggest that this spillover is due to a lack of structural flexibility in the workplace. However, many more women are affected by this lack of flexibility than are men, simply because a much larger percentage of women in the workplace are in dual-career marriages. It is proposed:

Proposition 4: Work–family conflict will negatively influence the choice of IT as a career in women.
Proposition 5: Work–family conflict will negatively influence womens' persistence in IT careers.
Proposition 6: Female IT workers will experience higher levels of work-family conflict than male IT workers.

Structural factors

Occupational culture

A large number of studies have focused on differences in computer education for boys and girls. These studies, in general, have concluded that many girls are turned off computers and left unprepared for and uninterested in computer careers (Wright, 1997). Many researchers have observed that this may be because educational, as well as recreational computer software is mostly written for boys' rather than girls' interest (Huff, 1987; Cooper *et al*, 1990; Maitland, 2001). Indeed, as Kiesler *et al* (1985) have stated,

> the culture of computing may be a reasonable expectation for the apparent difference in girls' and boys' attraction to computing. It is a world of electronic pool halls and sports fields, of circuits and machines, of street-corner society transmitted to a terminal room. This is hardly the kind of world girls find enticing'. (p 459)

Turkle (1995) has identified two 'dominant computer cultures' that have emerged since the mid-1980s – that of calculation and simulation. The culture of calculation tends to be rigorous and engineering in approach; it involved hard programming that is performed in a 'top-down' structured approach and is based on masculinity, 'mastery, individualism and nonsensuality' (Turkle,

1984, p 223). Simulation is more consistent with 'soft' style with which women are more comfortable (Turkle, 1995). She and others have suggested that culture of calculation is the dominant culture of computing (Wright, 1997) and it has been instrumental in turning off many women to the field.

This 'occupational-culture' prevalent in the world of IT in universities and colleges incorporates exceptionally long hours, late nights and 'highly focused, almost obsessive behavior' (Frenkel, 1990). For many women, this work ethic may conflict with their safety concerns and family responsibilities. The hackers who are predominantly male are seen as being 'bright and creative'. Women remain on the periphery of this dominant culture. Missing out on valuable interaction with faculty and colleagues can translate into missed opportunities for learning and participation in projects (Rasmussen & Hapnes, 1991). Rasmussen and Hapnes suggest that this type of culture is important in producing and reproducing male domination in higher education in computer-related fields and that it influences the integration of women and their position within the field of computing.

These and other factors have resulted in many high school girls perceiving computer work as a 'male field which is inhospitable to women' (Newton, 1991). I propose:

Proposition 7: The perception of occupational culture will negatively influence womens' choice of IT as a career.
Proposition 8: The perception of occupational culture will negatively influence womens' persistence in IT careers.

Lack of role models

At the career choice stage, where women make critical decisions about their careers, the presence of role models can be very instrumental in steering them in one direction or the other. By their very presence, role models provide evidence that a successful career in the field is a possible and unremarkable occurrence (Pearl, 1990). Since only 5% of upper management in the IT industry (Science, 1992) and 6.5% of faculty positions (Frenkel, 1990) are held by women, such guidance and support for female students is severely limited. Although I could not find such data for IS education in business schools, Camp (1997) has characterized the educational pipeline in computer science (CS) as the 'incredible shrinking pipeline' – due to the observation that not only does the pipeline shrink from high school to graduate school, bachelor's degrees awarded in CS to women have decreased almost every year over the last decade. In spite of a slightly upward trend in PhDs, only 15% of those were awarded to women in 1993–1994 (Camp, 1997).

Indeed, Pfleeger and Mertz (1995) have recognized that 'despite a host of efforts to attract and keep women and minorities in computing, they continue to be underrepresented across the several computer science disciplines' (p 63) and suggested that a major problem in attracting and keeping women in computing is the lack of role models at all levels, particularly at senior levels.

Educational and career encouragement has been found to be more important in women than in men (Tharenou *et al*, 1994). Given an environment into which girls and women may not be integrated, encouragement for advancement from role models has been found to be essential to increase womens' awareness of the education and training needed for IT skills.

Further, career choices in college are often made in consultation with faculty members. If female students lack female role models with whom they can discuss career choices with relationship to life-style implications, they may not feel they have complete information to evaluate their options in IT careers. Under such circumstances, female students may, by default, self-select themselves towards careers in which they observe other women, thus further intensifying the gender-based stereotyping of professions. Thus:

Proposition 9: A lack of role models will negatively influence womens' choice of IT as a career.
Proposition 10: A lack of role models will negatively influence womens' persistence in IT careers.

Interaction of social and structural factors

Social and structural factors interact to produce varied psychological and real barriers, which may inhibit womens' learning and comfort with using computers. The occupational culture interacts with social expectations to keep women outside the inner circles of IT. Limitations caused by work–family conflict may help reinforce the stereotype that careers are only a second priority for women. Social expectations may have a lower influence in presence of strong role models in the environment. Presence of role models may also facilitate a higher understanding of work–family conflict issues, further helping retention of women in the workplace. Further research is required to investigate the process by which the factors discussed in this section lead to demographical trends in the field of IT so that intervention can be targeted most effectively.

The relationship between social and structural factors is likely to be recursive. For example, job openings are frequently publicized through faculty members (who also act as role models). Faculty members may recommend students with whom they interact. Presence of work–family conflict is likely to reduce female students' interaction with faculty members. Faculty members may also perceive female students with work–family conflict as less suitable to an IT career than those who do have work–family conflict. Thus, work–family conflict may lead to reduced likelihood of being recommended for employment.

Evidence suggests that structured exposure to com-

puter software minimizes gender differences in attitudes and use in college freshmen while unstructured conditions (as represented by occupational culture of long hours and late nights) amplify this difference (Arch & Cummins, 1989). This early evidence needs to be investigated further and if found true should be incorporated in training programs.

It is encouraging that sufficient training, experience and lack of gender stereotyping may reduce the gender differences in computer anxiety, attitudes towards computers and computer usage (Stowers, 1995; Venkatesh *et al*, 2000). In line with these arguments, the following propositions are presented:

Proposition 11a: The relationship between social and structural barriers at career choice stage is likely to be recursive.
Proposition 11b: The relationship between social and structural barriers at career persistence stage is likely to be recursive.
Proposition 12: Computer training and structured support will reduce the negative effect of social expectations on attitudes towards computers in women.

Career advancement

After several years of work experience, men and women are considered ready for higher-level positions. I call this a stage of career advancement. To my knowledge, only one academic study so far has directly examined gender differences in career advancement in the field of computing (Igbaria & Baroudi, 1995). Broadly, they found that women experience more restricted career advancement than men. In contrast, men experience more favorable career opportunities than women do. Further, they reported that while the career advancement prospects were less affected by job performance ratings but more on job attributions (performance attributed to ability, hard work, etc) on career advancement prospects is stronger among women. Gender biases in attributions are likely to be invoked only when womens' high job performance ratings violate gender-roles stereotypes and expectations (Heilman & Stopeck, 1985). Calling for more research in this area, Igbaria and Baroudi (1995) suggest that career advancement opportunities for men and women can be evened out if similar criteria were used for both groups.

Providing support for existence of barriers at this stage, Shuttleworth (1992), in her study investigating the role of traditional attitudes to women, education and training, reported that while 10% of males in the survey had achieved senior managerial positions, only 3% of females had been able to do so. Researchers have found that while men experience some greater task-related developmental challenges women experience developmental challenges stemming from obstacles they face in their jobs (Ohlott *et al*, 1994). In a similar vein, Ragins and Sunderstrom (1989) longitudinally examined career transitions in the development of power among men and women and found a consistent difference favoring men in accessibility to, and utility of resources for power. They suggested that the processes involved in the development of power differ for men and women and that the path to power for women resembles an obstacle course. A related point is that rank is directly related to power (Ragins & Sunderstrom, 1989) and the fact that fewer women exist at the higher ranks results in fewer women having access to power echelons in the organizations.

Ragins and Sundstrom (1989) propose that several organizational factors might account for gender-based differences in advancement. These include performance appraisals that have traditionally been tailored to a male pattern of advancement, as well as selection of men for jobs and training that are likely to lead to advancement.

With respect to advancement of women in IT careers, structural barriers are the hardest to overcome. Yet, social barriers still play a major role. The main social barrier is lack of participation in informal networks. I believe that work–family conflict continues to be a barrier, but is not as overpowering as it may have been at the career choice stage. This is because child-rearing becomes less consuming as children grow up, and because by this time, many women may have established mechanisms for managing issues related to work–family conflict (eg seeking hired help). Work–family conflict has been discussed extensively in the previous section and will not be discussed here. Two structural barriers that are considered important in the context of IT careers are a lack of mentors and the changing structure of IT industry itself.

Social factors

Informal networks

Informal networks have long been recognized as important in career advancement (Smith-Lovin & McPherson, 1993). These informal networks can serve several purposes, ranging from obtaining information regarding opportunities in the organization to socialization in the organizational culture. Informal networks may have a reciprocal relationship with mentoring, which is discussed in the next section. For example, they allow a protégé to be exposed to potential mentors. On the other hand, a mentor is a link for the protégé to gain entry into the social networks within the organization. However, Ragins and Cotton (1991) have shown that corporate informal networks are primarily made up of men. While the lack of access to informal networks may play a role in women choosing IT as a career (organizations often rely on informal networks for recruiting), this factor becomes increasingly important for advancement within the organization and within the field. These informal networks are effective tools for

male advancement that had been established before women started climbing the professional ladders. Some of this network, often referred to as the 'old boy's club', is based on masculine activities, which reflect traditional social and cultural roles, such as sports talk, golf tournaments, etc, and other shared experiences as a means for building camaraderie. Unfortunately, the failure of women to achieve upper-level positions or gain access to those in such positions tends to perpetuate the established informal network structures. As studies suggest, women are often left out of these informal networks of 'power sharing and dissemination' across industry and academia (Kram, 1983; Ragins & Cotton, 1991).

Gallos (1989) has observed that while career development for men typically translates into increased autonomy and separation from others, career development for women is tied more to attachments and relationships. Gallos further suggested that while relationships are important for men in later career stages, when they face immortality and generativity issues, relationships are important for women throughout their careers. In a study of 189 male and 78 female executives, Van Velsor and Hughes (1990) found that women reported a greater reliance on work relationships as sources of development and learning.

The above leads to the following:

Proposition 13: During the career advancement stage, a lack of female-friendly informal networks will negatively influence womens' advancement in the field of IT.

Structural factors

Mentoring

Researchers and practitioners alike have expressed concern that the IT field is not developing and advancing enough women to the higher ranks. One reason for this may reside in a lack of mentoring opportunities for women. If we are to ensure that organizations select their employees from a complete and broad pool of human resources, they must ensure that women employees have ample mentoring opportunities.

Mentoring has been found to be critical in the advancement of professional careers (Kram, 1983; Dreher & Ash 1990). Mentoring is 'an intense developmental relationship of relatively long duration in which protégé receives a range of career and psychological help exclusively from one senior manager (Levinson *et al*, 1978; Clawson, 1980; Kram, 1985)' (Whiteley *et al*, 1991, p 133). A mentor is 'an experienced, productive manager who relates well to a less-experienced employee and facilitates his or her personal development for the benefit of the individual as well as that of the organization' (Noe, 1988, p 65). This relationship may be formal or informal.

In general, research has shown that although women can benefit as much from mentoring as men, there is a lack of female mentors in organizations (Warihay, 1980; Noe, 1988; Ragins, 1989; Parker & Kram, 1993). It has been suggested that the number of mentoring relationships (mentorships) available to women does not appear to be keeping pace with the increasing number of women needing mentors (Shockley & Stanley, 1980; Berry, 1983). I argue that a proactive facilitation of mentorships may be beneficial for development and advancement of women in IT careers. While several studies have successfully demonstrated the effect of mentoring on womens' advancement in various areas (Kram, 1983; Burke, 1984), to my knowledge, no studies have been conducted to assess its effect in the field of IT.

Research has suggested that women face more gender-related interpersonal and organizational barriers in their obtaining a mentor than men (Kram, 1985; Ragins, 1989; Ragins & Cotton, 1991). Some researchers suggested that the lack of female mentors in organizations could be explained by the fact that women in high positions do not want to share the limelight with others and because competitive feelings toward other women prevent them from filling this role (Powell & Mainiero, 1992; Gallese, 1993; Parker & Kram, 1993; Ragins & Scandura, 1994, p 966). Counter to these suggestions, Ragins and Scandura (1994) found that the desire to become a mentor is as strong for women as it is for men.

There may be some other factors that can explain a lack of mentoring for women in organizations. One explanation for a lack of mentors for women can be found in the theory of interpersonal attraction. The theory of interpersonal attraction posits that individuals are most comfortable interacting with those who are similar to them (Dreher & Ash, 1990). This theory suggests that similarity with another person yields more favorable perceptions of and greater liking for that person (Heider, 1958). Similarity to others has been linked with several individual and organizational outcomes. Kirchmeyer (1997) found that similarity to others at the same managerial level in terms of gender, culture, age and education determined career progression and perceived success over time. A lack of women at higher ranks therefore may have a negative influence on advancement of women at lower and middle levels. In other studies, dissimilarity has been linked with turnover (Kirchmeyer, 1997).

This theory has indeed been empirically tested in the context of mentoring relationships. This research has suggested that gender similarity is a key factor in the success of mentoring relationships, and a lack of women available to mentor other women is generally detrimental to womens' professional development. The research has further shown that men and women prefer interacting with members of the same sex in the work environment (Larwood & Blackmore, 1978). As a result, 'women

may find themselves without a mentor because male managers may prefer developing mentorships with male subordinates' (Noe, 1988, p.70). Kram (1985) also concluded that men and women find it more comfortable to mentor protégés of the same gender. Researchers have suggested that men may sometimes be afraid to mentor women because of the greater risk that stems from the perception that women tend to be highly visible and to attract attention. The senior managers may perceive a greater risk of receiving adverse publicity which could stymie the attainment of his or her own career goals, if the mentorship is unsuccessful (Noe, 1988).

A final reason for a lack of mentors may be that women have less access to informal settings necessary for initiating and building mentor relationships (Hunt & Michael, 1983). Further, traditional expectation for women is to take a passive role in initiating relationships (Hill *et al*., 1989).

It is important to consider and perhaps counter the trend discussed above because mentoring appears to be related to a number of organizational and individual-level outcomes including promotion (Dreher & Ash, 1990; Whitely *et al*., 1991), incomes (Dreher & Ash, 1990), career mobility (Scandura, 1992), career satisfaction (Fagenson, 1989), and finally, pay and benefit satisfaction (Dreher and Ash, 1990). One way to do this is to better understand the factors that make a mentoring relationship effective.

Riley and Wrench (1985) have reported that women who had one or more mentors experienced greater job success and job satisfaction than women who did not have a mentor. Some researchers have argued that the benefits of mentoring may be amplified for women. Consider the following statement made by Ragins and Scandura (1994), 'women may expect and receive greater benefits from the mentoring relationship than men, not only because the relationship meets their developmental needs, but also because mentoring role expectations are more aligned with gender role expectations for women. Specifically, the essence of mentoring involves helping protégés and nurturing their development. These behaviors are certainly aligned more with traditional female than male gender-role expectations' (p 960).

As suggested above, if mentoring is important for any worker, it may be even more important for women in the sense that it could help women to overcome advancement barriers (Kanter, 1977). In general, women face more gender-related interpersonal and organizational barriers in their obtaining a mentor than men (Kram, 1985; Ragins & Cotton, 1991). Women have less access to informal settings necessary for initiating and building mentor relationships (Hunt & Michael, 1983). Other reasons for this may be that men and women find it more comfortable to mentor protégés of the same gender (Kram, 1985) and the traditional expectation for women to take a passive role in initiating relationships (Hill *et al*, 1989). Thus:

Proposition 14: A lack of mentors will negatively influence womens' career advancement in the field of IT.

Organizational/institutional structure

Another factor that has a life-long effect on womens' professional careers is the structural forces at work within organizations. One measure of womens' underrepresentation at the top is board membership. In general, researchers have found support for the gender bias in board memberships (Bilimoria & Piderit, 1994). It is important to pay attention to this bias because it represents 'the failure of corporate board leadership to recognize the competitive advantage represented in the systematic recruitment of women from the corporate sector' (Burke & Mattis, 2000, p 154). Some researchers have tried to examine the reasons behind this lack of women in corporate boards. For example, Kent and Moss (1994) studied effects of gender and sex role on self- and group-perceptions of leader emergence. In addition to biological gender, they examined sex-roles based on personality traits. Interestingly, subjects possessing androgynous and masculine traits were the most likely to emerge as leaders. In other words, personality traits that are perceived as feminine were found to be detrimental to advancement of men, as well as women.

Current competitive forces such as globalization and the flattening of organizational structures may have served as impediments to the magnitude of opportunities for women in certain industries including information technology (Burris, 1989). Women are typically perceived to be family-oriented and unwilling to travel (Blum & Smith, 1988). As many firms become global, promotional paths require an international assignment for which many women are not considered (Adler, 1984). Women currently represent only 3% of expatriate managers, and Adler's (1984) work suggests that this may be due to the perception of male managers that women will not be accepted in this role rather than womens' refusal of international assignments. Thus, recent trends in IT towards globalization combined with the perceptions of womens' unwillingness or inability to travel may have hampered womens' chances of being hired for positions that require travel.

Another trend concerns changes in organizational structures. Several organizations have flattened their structure by eliminating many middle management positions which represented promotional opportunities for professional women and men who entered these organizations during the 1970s and 1980s (Blum & Smith, 1988). Empirical evidence linking contextual aspects of organizations such as existing social structures, personnel and compensation practices, and womens'

advancement in organizations exists. In fact, Blum *et al*. (1994) found that structural factors accounted for almost half of the variation in the percentage of higher management positions filled.

Specifically in the IT field, Fryxell and Lerner (1989) analyzed the characteristics of firms that have under-represented groups in top management positions and those that do not. They found that firms engaged in high-tech areas needed far more women than the firms in other fields. Thus:

Proposition 15: Institutional structures will negatively influence womens' career advancement in the field of IT.

Interaction of structural and social factors at career advancement stage

A lack of adequately experienced women is often cited as the prime reason behind absence of women from upper management levels. To the extent that this might be true, leaks in the pipeline at career choice and advancement stages may contribute to this situation. Stereotypes of women not wanting to travel may lead to low recruiting of women in high-level positions requiring international travel.

Men and women in powerful positions can provide greater access to powerful coalitions. Further, attainment of power and critical inter-personal relationships can, in turn, increase career aspirations. However, women miss out on these pathways to advancement because a disproportionately low number of women in upper management levels contribute to a lack of mentors for junior IT professionals and acts as a barrier to attainment of access, power and higher aspirations (Ragins & Sundstrom, 1989).

In spite of improvements in favorable social norms, as well as organizational awareness of work–family issues, women are still mostly expected to be primary caretakers in households. A lack of flexible work structures (eg not allowing employees to work on their schedule) can result in organizations facing absenteeism. Employers may expect them to leave or reduce work hours after childbirth, and thus may not promote them to critical positions. Some women may, in fact, be discouraged by their perception of inequity and may turn to more rewarding roles, such as motherhood. All these factors may reinforce the stereotype of women being more committed to family than to their employer. Some women may try harder to make it up the corporate ladder, and thus increase the level of work–family conflict in their lives, which can then lead to negative organizational attitudes and commitment.

Based on the above, a final proposition pertaining to career advancement stage is:

Proposition 16: The relationship between social and structural barriers at career advancement stage is likely to be recursive.

Contribution and a proposed research agenda

The model presented here synthesizes the literature relevant to the area of womens' status of the field of IT and presents a general research agenda of barriers to womens' entry, persistence and advancement. The core contribution is the movement toward a testable model of measurement and assessment issues involved in the study of these barriers.

The proposed framework implies three basic research phases necessary to answer the conceptual, empirical and analytic questions. At the conceptual level, it is important to assess whether the three stages of career choices, career persistence and career advancement in IT are distinguishable. The assumption here is that the nature of these barriers is cumulative and incremental; that is, women drop out of the computer career pipeline at several different points and the entire variance for this attrition can not be found in one place.

At the empirical level, adequate measures for factors involved at each stage need to be developed and modified to fit the IT field. Fortunately, scale development should not be too difficult an issue as general validated scales for work–family conflict, mentoring, computer anxiety, as well as many other constructs I have discussed already exist (Wiley, 1987; Gutek *et al*, 1991; Frone *et al*, 1992; Thomas & Ganster, 1995; Adams *et al*, 1996).

Other factors may be somewhat more difficult to measure, such as female friendly networks. One way the presence or absence of female friendly network can be assessed will be through examining men and womens' perceptions of the same. The researcher can ask women if they feel that the social networks are dominated by men and whether they feel at home in the existing social networks. Similarly, researchers could ask men if they consider women welcome in the existing social networks (within a group/department/company). Example of potential items for this scale may be:

1 Managers here give feedback and evaluate employees fairly regardless of the employee's ethnicity, gender, age, or social background.
2 In this organization, I feel at ease with people of different sexes other than my own.
3 I feel like an outsider at the social gatherings in our department.

Many specific empirical questions can be formulated around career choice, persistence and advancement stages. With regards to career choice and persistence, while educational aspects have received some attention in the past, relatively little attention has been paid to social expectations and attitudes that may act as barriers to IT career entry. For the most part, this research has focused on the effects of computer anxiety. It is

important to examine the sources of anxiety so that preventative and remedial measures can be taken. One reason why this is the case may be rooted in the difficulty of measurement and need for longitudinal studies. I have hypothesized a mediating effect of attitudes on the relationship between social expectations and womens' choice of IT careers. I call for longitudinal studies to test these relationships. In the meantime, studies based on recall may guide us towards an understanding of this area.

To further advance research in this area, a model linking work–family conflict with attrition and advancement in IT presents a fruitful avenue for research. Potentially, researchers could further test the moderating effect on this relationship of organizational facilitation of different career paths and other structured support for work–life balance. This can be done cross-sectionally to investigate the effects at each specific stage as well as longitudinally to examine the cumulative and comparative effects of work–family conflict on performance, innovativeness and commitment to IT careers.

The career advancement phase involves assessing the impact of mentoring, informal structures and organizational structures on attrition and womens' advancement. Study of career advancement has largely been ignored in the IT literature. Mentoring has been studies extensively in organizational literature, and designing studies of mentoring can be achieved based on the existing literature. New organizational work structures, such as flexible work hours, alternative career paths and telecommuting are beginning to receive attention. Impacts of these on retention and advancement should be assessed. One danger of these flexible work structures may be a further exclusion from informal networks.

It is important to identify contextual variables that are more conducive to retention and advancement of women. The effects of retention and advancement of women on adoption and implementation of new technologies needs to be assessed. I propose that an organization featuring equal participation of women will be more successful in its innovation and implementation efforts.

The above is meant to provide illustrations of how individual barriers can be tested for their influence on the turnover and advancement of women in IT. I encourage researchers to empirically test the propositions presented in this paper. Of course, many more studies are possible and needed.

The model presents several analytic and methodological challenges. Throughout, we have proposed recursive relationships between social and structural factors. Testing these types of relationships is an analytical challenge. The way to examine this recursive relationship is through longitudinal studies. As with most process models such as this one, longitudinal studies are required to capture the full complexity of the model (Mohr, 1982). It may be, however, difficult to conduct a single longitudinal study to include all three stages. Stage-wise investigation of variables and processes involved may be more practical. In planning and implementing empirical studies based on this framework, future researchers can make judgments regarding the practicality of the analysis and may chose to conduct either single or a series of cross-sectional studies, or they may chose to conduct longitudinal studies, that can allow for testing of causality among these factors.

This model lends itself to both qualitative methods to study the processes and quantitative methods to study the empirical relationships between variables. Examples of qualitative methods that can be used are in-depth case studies, interviews and participant observation. Case studies and participant observation are suitable for examining factors such as organizational climate and its effect on womens' advancement in the ranks. Researchers can also interview men and women to identify their perceptions of the work environment in a given organization. Survey and interview techniques can be utilized to test the effect of structural factors such as mentoring. For example, if the employee perceptions of mentoring opportunities available to them can be empirically linked with relative advancement of men and women, that would provide support for part of the model. Finally, experiments can be performed to test the effects of individual barriers on career choice, attitudes, learning and advancement. For example, the effect of software orientations on stress levels and learning can be tested using an experiment.

Additionally, I propose the use of social network analysis to identify participation of men and women in the existing influence networks in the organization. Social network studies have repeatedly proven useful in identifying informal networks that prevail in organizations. These social networks have been proven to possess more explanatory power than formal hierarchies.

Perhaps the biggest limitation of this model is the difficulty of separating the external influence from individual freedom. It must be acknowledged that the nature of the proposed model is deterministic. The influence of external factors does not imply an absence of individual choice and control. While I think that the model presented here may explain significant variance in the phenomenon, it can not explain all variance.

Another limitation relates to the significant problem presented by limited applicability of the findings from previous gender differences research, typically from the 1970s and 1980s. This paper, too, cannot escape this problem. In absence of empirical data to support the model, this problem is further aggravated. As more research is done in this area, I am optimistic that more relevant literature will become available for future researchers.

Another issue of concern is the choice of level of analysis in testing this model. The individual level of

analysis would appear to be appropriate to test the model presented here. However, phenomena explored here operate at a micro, as well as macro level and investigating such phenomena can pose difficult questions.

In conclusion, this paper has presented a framework for examining womens' choice, persistence and advancement in IT careers. It is believed that it is critical to consider the reasons for the lack of womens' participation in this leading-edge industry. Identifying specific factors responsible for loss of valuable human resources, as outlined in this paper, will be useful in guiding policy decisions concerning the performance of women in IT, as well as in helping us fight the labor shortage in the IT industry. In addition to implications for IT labor shortage, as Schwartz has suggested 'womens' issues are really business issues' (Shwartz, 1992). This paper has provided an early step in the direction of increasing womens' participation in the IT industry.

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