Development of gender-specific technologies: Evidence from China, Poland and Sweden

Göransson, Bo; Rolfstam, Max

2009

Development of Gender-Specific Technologies. Evidence from China, Poland and Sweden

Bo Göransson
Research Policy Institute
Lund University, Sweden
Bo.Goransson@fpi.lu.se

Max Rolfstam
Research Policy Institute
Lund University, Sweden
and *SPIRE*
University of Southern Denmark
Maxr@sam.sdu.dk

Abstract

The broader interest and also the novelty of the research discussed here concerns gender aspects of technology use in the innovation system. The generic question that drives this research is to what extent it is necessary to distinguish between women and men in the use of technology. A second question is, if gender-specific differences exist, to what extent is the innovation system capable of utilizing experiences also from women. The empirical data presented here on women as innovators and users of technology indicate that there indeed exist differences in preferences between genders and that the innovation systems have been slow or incapable of exploiting these differences with a consequent welfare loss to society.

Introduction and background

In January 2006, the project *Women Scientists in Gender-Specific Technological R&D – How do Women Scientists in Technological R&D Respond to the Needs of Women End-Users?* (WOSISTER) was launched. The project aimed at clarifying the process of how women scientists engaged in technological R&D respond to the needs of women end-users. In other words, how is demand by women end-users articulated and taken up by women researchers? Two sets of technologies – agricultural equipment for rural application and teleservices – were selected as case studies; one set representing mature,

low-technology and the other high-technology. The case studies were carried out in two transition economies - Poland and China – together with Sweden as a reference country.[1]

The Polish and Chinese societies are experiencing a rapid economic and technological transition. Demand for technology is diversifying and the structures of end-users in different technological fields are being re-shaped. In the process, women in China and Poland as well as in Sweden have become an important user group for technical applications both in the traditional agricultural sector and the rapidly growing telecommunications sector. This development would appear to require more gender-specific R&D and the harnessing of social capital of women in R&D. An attractive environment for investors and strong scientific bases should make both China and Poland significant actors in technological research. Women have equal opportunities for higher education in these countries and in Poland and Sweden, younger women are generally better educated than men. Yet they are poorly represented in scientific research and particularly in the fields of engineering and natural sciences (Gras-Velazquez 2009).

The broader interest and also the novelty of the research discussed here thus concerns gender aspects of technology use in the innovation system. The generic question that drives this research is to what extent it is necessary to distinguish between women and men in technology use. A second question is, if gender-specific differences exist, to what extent is the innovation system capable of utilizing experiences also from women.

In this paper we will present empirical data on women as innovators and users of technology. The point of departure for the paper is the globally relatively modest level of inclusion of women in research and development, and the perceived neglect of taking into account women end-user needs in technical development. It may be suggested that as women are poorly represented both as developers of technology as well as a specific user group of technical applications, technology has historically tended to be developed by

[1] The project was carried out jointly by research teams from Institute of Production Systems Organization, Warsaw University of Technology, Polen, team leader Professor Jarosław Domański, Poland; Chinese Academy of Science and Technology for Development, Ministry of Science and Technology, China, team leader Dr. Zhou Yuan; and Research Policy Institute, Lund University, team leader and coordinator Dr. Bo Göransson.

men, for men. From the perspective of national systems of innovation this would imply that the capacity for technological development is not fully utilized and that there is a pent up innovation potential in the innovation system. Moreover, it can be argued that in today's much heralded march towards a knowledge society, a country can ill afford to miss out on the quantitative as well as qualitative innovation potential represented by women as innovators and as a specific group of users of technology.

The paper is organized into three sections. In the first section, the main results of national surveys of women researchers and their engagement in research aimed at a specific gender are presented for the three case countries. The following section details the findings of the surveys of end-users of the selected technologies. Finally, the implications of the findings are discussed and policy recommendations are offered.

Results from national surveys of women researchers in gender-specific research

During 2007 and 2008, interviews with women researchers were carried out in the three case countries – 170 in China, 128 in Poland and 60 in Sweden respectively. The objective of the interviews was to make a quantitative study of how, and at what stage of the R&D process, interaction between end-users and researchers take place. How are customer preferences integrated into the product development process? At what stage of the development of technology do user/gender considerations enter, if at all?

A questionnaire was jointly developed by the research teams from Warsaw Technical University, Poland, Chinese Academy for Science and Technology for Development, and Lund University, Sweden. In Poland and China, each respondent who completed a questionnaire was also interviewed. In Sweden, some respondents were selected for in-depth interviews. Most interviewees were researchers from the agricultural sector, a smaller sample from the ICT sector. Research institutes, corporate R&D units, state

university were all represented. The questionnaire also identified age and level of education and experience.

Since no complete database over women researchers in these fields existed in any of the three countries, the 'snowball' approach was applied in the sample selection process. An initial group was identified using available information on research institutes, university departments and companies active in these fields. These institutions were contacted and asked to participate in the survey. All interviewees were then asked to suggest other persons to contact.

This selection procedure, together with the limited size of the sample, means that from a statistical point of view, we can not with certainty draw conclusions about the full population. However, the sample included in the quantitative questionnaire survey, together with the complementing personal interviews, still provide results that are strong enough for qualitative inference about the occurrence of gender-oriented projects in technological R&D in the target fields and about the participation of women researchers in these projects.

Summarizing of the main findings of the surveys:

1. End-user preferences are generally taken into account through feed-back mechanisms at all levels of product development

As might be expected, researchers working with product development depend on feed-back from end-users to perform their work. The question is when such interaction between developer and consumer takes place. Perhaps surprisingly, we did not see any significant differences in levels of feed-back mechanisms along the timeline of the product development phases, i.e. the research stage (the discovery of new knowledge), the development stage (developing the technical functionality of the product) and the design stage (modelling, shaping and re-designing the product). In other words, user preferences are an important instrument for researchers at all stages of the product

development phase and is not confined to the later, sometimes cosmetic, stages of a products development cycle.

2. Gender is often not considered in determining user preferences

In the interaction between product developer and end-user, gender is generally not regarded as an important issue. This is particularly true in the telecom sector where gender is not considered a factor and technology is regarded as generic or gender-neutral. In Poland 74% of respondents did never consider gender explicitly in user interactions. In Sweden and China the numbers were lower, 29 and 10 % respectively.

It is interesting to note that in the cases when gender *was* considered, different preferences between genders were identified in 76 % (Sweden) and 45% (Poland) of the projects.

3. Few gender-specific projects are being proposed

The survey found few examples of gender-specific project proposals. i.e. project aimed at a specific gender. China provided the highest rate of these projects. However, the few examples that were identified seem to have a quite high success-rate. In Sweden, 7 of the 8 cases of gender-specific product developments were rated as successful.

4. The level of interest towards gender-specific research tends to fall with age

We could see a clear tendency of falling interest with age in pursuing gender-specific research – older researchers did not perceive gender to be as important a factor as the younger generations. In China we also observed a tendency of lower interest correlated with lower experience in the agricultural sector but an increase with experience in the telecom sector.

5. Type of research organization

Regarding differences in where the research was performed, it appears that in Poland, university research was more gender sensitive, i.e. open to the idea of different patterns of usage and preferences for technology between genders, whereas in China the market

oriented companies were more sensitive and State-owned institutes less gender sensitive. In Sweden, no difference could be seen.

In conclusion, we found that there is a great interest in the general subject of the degrees of freedom for women researchers – in particular among women researchers. However, there is also a generally low interest for gender-specific technological development among men and women researchers alike, even though the few examples that we found in gender-specific technological development appear to have a high rate of success. Users are regarded as a homogenous group in terms of technological development – a case of ”technology fits all”.

If technology indeed is generic, we would expect no gender difference in preferences among users of the technology and, thus, no need for catering specifically for a specific gender. To test this, we looked closer at some selected technologies in the three case countries.

Users of technology

A central notion for understanding the dynamics behind scientific development as well as technological development is interaction. For example, the chain-linked innovation model proposed by Kline and Rosenberg (1986) emphasizes the interaction and feedback that is going on between basic research, invention, innovation and production. This understanding is also central to systemic views of innovation (Lundvall, 1982). The non-linearity is also captured in studies of innovation resulting from user-producer interaction (von Hippel, 1988).

From this understanding the user of a specific technology becomes important for innovation not only as a passive consumer. By learning from users, a supplier can make incremental improvements of existing products. User experiences may also be potential sources for stimulating new development of technology as well as basic research. Understanding user need was also central to the cooperative approaches to computer

system design developed in the 1980s in Scandinavia (Greenbaum and Kyng, 1991). Emphasizing the user, i.e. the customer is also justifiable from a strategic perspective. It makes sense for firms to collaborate with the people and organizations which essentially are the reason why a company exists – their customers (Prandelli, Sawhney, Verona, 2008).

Methodology

A questionnaire was developed with the purpose of exploring if and how women and men working in agriculture perceive selected technologies differently in their daily usage. 5 technologies common to the farming communities in the three countries were selected: tractors, milking machines, animal feed, fertilisers and mobile phones. For each technology the respondents were asked to rank – on a scale of 1 to 5 – how easy or useful they perceived different aspects of using and maintaining the technology.

The questionnaire consisted of multiple choice questions and took about 15 minutes to complete. Possibilities for comments to each question were provided, to allow clarifications.

Due to practical reasons the methodology in the different surveys were slightly varied between the countries. In China and Poland, face-to-face interviews were carried out. In the Swedish case data was collected through a mail survey based on a randomized selection of farmers registered at Statistics Sweden as applicants for EU agriculture grants (table 1).

Table 1. Overview over sample characteristics

	China	Poland	Sweden
Selection	Shandong province and Hubei province	51 polish local agricultural units (gminy wiejskie) representing all polish regions (voivodships)	Randomly selected from a database provided by statistics Sweden
Data Collection Method	Field survey	Field survey	Mail survey
Time for Data Collection	Summer, 2008	February, 2008	Mid November – End of December, 2007
Database	130 females 370 males = 500 respondents	290 females 114 males = 404 respondents	205 females 259 males = 464 respondents

Use of Technology in General

When it comes to tractor use among farmers, the general pattern in the sample is clear. Men do in general use tractors more than do women. In the Swedish sample almost all male farmers, 98% were also tractor users. 67% of the women in the Swedish survey stated that they use tractors. Although Swedish women use tractors less than Swedish men, they still use tractors relatively more than women in Poland and China. 45% of the women in the Polish sample stated that they use tractors, while most of Polish men, 94% stated that they use tractors. Also in China males in general use tractors more than women do. 89% of the men in the Hubei province and 93% of the men in the Shandong province stated that they use tractors. The corresponding figures for women were 23% and 32% respectively (table 2).

Concerning the other technologies studied, the role gender plays as a determinant for usage, varies. The technology that seems to be closest to tractor use in terms of gender distribution is use of artificial fertilizers. For all countries, males handle artificial fertilizers to larger extent than females. In the Chinese provinces 99% (Hubei) and 97%

(Shandong) of males reported usage as compared to 67% (Hubei) and 61% (Shandong) of the females. Most males in Poland (94%) reported usage of artificial fertilizers. 74 % of Polish females reported usage of artificial fertilizers. Although females in the Polish sample use artificial fertilizers less than Polish males, the difference is relatively smaller than the Polish gender difference of tractor usage. For Sweden, use of artificial fertilizers was reported by 50% of males and 31% of the females.

For all countries milking machines are mainly operated by females. In China 35% (Hubei) and 42% of females reported use of milking machines, while the corresponding share among males was 24% (Hubei) and 32%. In Poland 31% of females and 25% of the males stated that they use milking machines. In comparison to the other countries milking machines are used relatively limited in Sweden. Only 9 % of Swedish males and 13% of Swedish females stated that they used milking machines.

Concerning use of animal feed, the gender differences for each country were relatively modest compared to differences in other technologies in the specific countries discussed above. Although the gender differences found are hardly discernible, apart from Sweden, the tendency would be that females to larger extent use animal feed than men. In China, 74% (Hubei) and 76% (Shandong Province) of males reported use of animal feed while the corresponding share among female respondents was 77% (in both provinces). In Poland 72% of the males and 73 % of Polish females confirmed use of animal feed. In Sweden, 80% of males as compared to 70% of females stated that they use animal feed.

The gender differences were also relatively small for (work-related) use of mobile phones. The relative use of mobile phones among the Chinese respondents was higher than the two European countries. In China, 93% (Hubei) and 90% (Shandong) of males stated that they use mobile phone. The corresponding share among Chinese females was 90 % and 89% respectively. 56% of Polish males and 55% of Polish females stated that they use mobile phones whereas 75% of Swedish males and 66% of Swedish females reported use of mobile phones in their work.

When it comes to sharing experiences, the gender differences are relatively small in China, but much clearly visible in the Polish and Swedish results. The result also suggests that Chinese users in general share their user experiences much more than in Poland and Sweden. In the Chinese case 76% (Hubei) and 75% (Shandong) of males stated that they share user experiences. Of Chinese females 70% (Hubei) and 71% (Shandong) stated that they share user experiences. In the two European countries, females tend to share user experiences less than males. Of the Polish males, 38% stated that they share user experiences while the corresponding figure for females was 23%. Sweden is the country were user experiences are least shared with (only) 21% of the males and 13% of females reporting doing so.

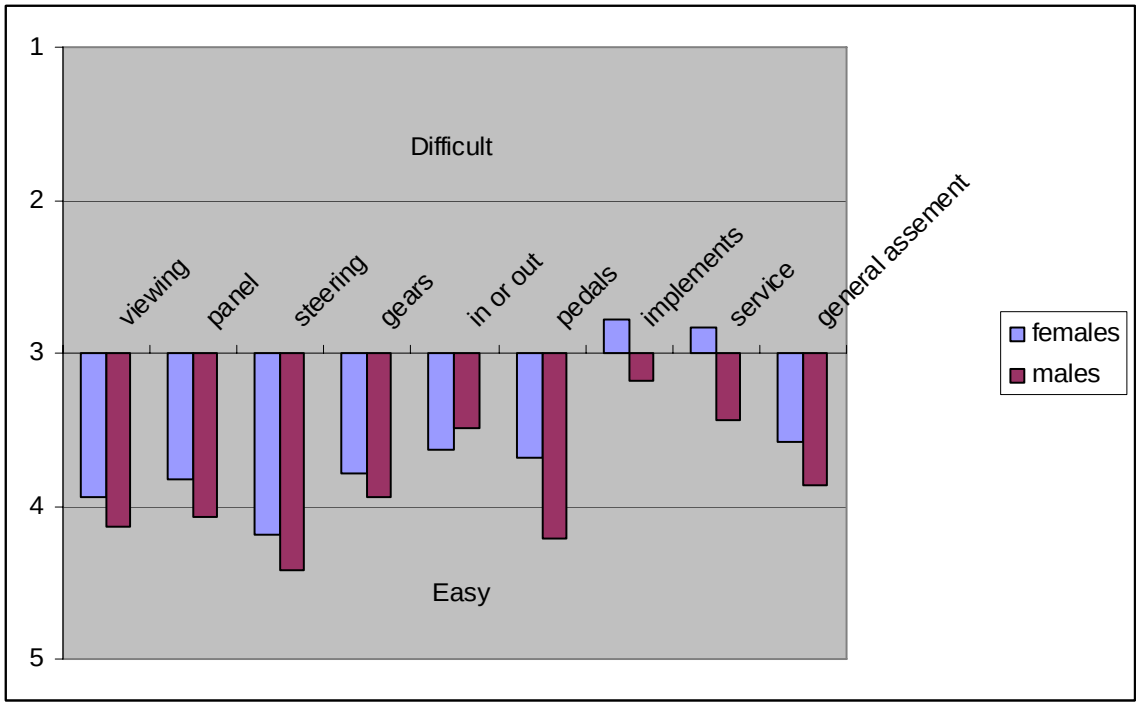
Table 2. Technology use and gender

	China		Poland	Sweden
	Hubei	Shandong Province		
Tractor Use and Gender				
Males	**89%**	**93%**	**94%**	**98%**
Females	**23%**	**32%**	**45%**	**67%**
Use of Milking Machines and Gender				
Males	**24%**	**32%**	**25%**	**9%**
Females	**35%**	**42%**	**31%**	**13%**
Use of Artifical Fertilizers and Gender				
Males	**99%**	**97%**	**94%**	**50%**
Females	**67%**	**61%**	**74%**	**31%**
Use of Animal Feed and Gender				
Males	**74%**	**76%**	**72%**	**80%**
Females	**77%**	**77%**	**73%**	**70%**
Use of Mobile Phones and Gender				
Males	**93%**	**90%**	**56%**	**75%**
Females	**90%**	**89%**	**55%**	**66%**
Sharing Experiences and Gender				
Males	**76%**	**75%**	**38%**	**21%**
Females	**70%**	**71%**	**23%**	**13%**

Source: Calculations based on survey results.

Use of tractors

For all three countries, women tractor users in general perceive tractor use as more difficult than men. In general what stand out as relevant differences between genders are those aspects of tractor use that requires some practical/technical skills apart from merely operating or driving the vehicle. Service and maintenance are examples of such tasks. Both in the Polish and the Swedish case women tractor users find handling implements relatively more difficult than men do in their specific country. Both Polish women and Swedish women rated handling implements below 3 (i.e more difficult to handle) while their male counterparts tended to find it easier to handle (see Chart 1 for the Swedish case). When it comes to maintenance and service the results for all countries are consistent. Female tractor users in general find maintenance more difficult then do men. What is noteworthy is that for both Poland and Sweden, men on average reach a rating that is above 3 for service and maintenance. In China, also men on average find service and maintenance difficult, although less difficult than females. To some extent this may be explained by the owner structure in the countries. In Sweden, in many cases one can assume that the male tractor users also own their tractor. Also, since long, tractor use has been integrated in Swedish farming and the technology per se has been used by also small farms for many years. In China, especially when it comes to farmers with an age over 50 years, tractor use experiences are very scarce, because few farms could afford to buy tractors.



Source: Calculations based on survey results.

Note: On vertical axis:
1=VERY DIFFICULT
2=DIFFICULT
3=NEITHER EASY NOR DIFFICULT
4=EASY
5=VERY EASY

Chart 1: Average assessments of difficulty of tractor operating by females and males in Sweden

Milking Machines

As given in table 2, for all countries, women use milking machines more than do men. In general, both women and men find using milking machines relatively easy. In general the viewpoints on the different aspects of using milking machines did not vary particular much by gender. The assessment of Lifting/applying, operating and cleaning were relatively similar between genders. In the Chinese case, the viewpoints are more or less the same for these aspects. The biggest difference among genders for all countries is the assessment of service of the equipment, where men in general find it easier than women (Chart 2).

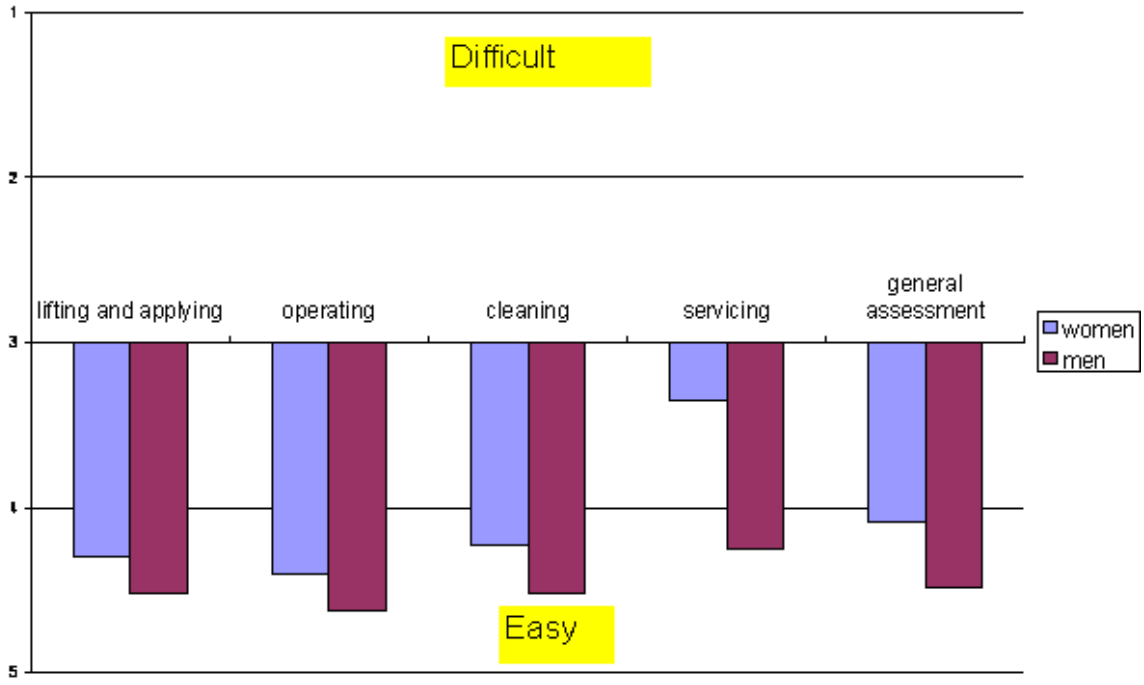


Chart 2. Polish assessment of using milking machines.

Artificial Fertilizers and animal feed

As was seen in table 2, the use of artificial fertilizers seems to vary between the countries. Among the Chinese and Polish males responding over 90% stated that they use artificial fertilizers. The corresponding share for Sweden was 50%. One gender-specific difference concerns the lifting of the containers. Women in Poland as well as in China rated lifting containers below 3, i.e. difficult. Also in Sweden, men in general found lifting relatively easy in comparison to how this was perceived by Swedish women. The average value given by Swedish women, unlike women in Poland and China, was however over 3. Still, the general pattern that women in general find lifting containers more difficult than men do prevails for all countries.

The fact that Swedish women on average rate the lifting of bags of fertilizers as easier than do women in the other countries is probably explained by technical circumstance and institutional factors, which have affected the design of bags used to carry artificial

fertilizers and animal feed. The most common type of bag is large bags containing 700 kg. These are moved by using a tractor. Although smaller bags may be used, Swedish work regulations do not permit usage of bags larger than 25 kg. This is clearly an improvement of working conditions. In the past, farmers could have to face to deal with bags with a weight between 50 – 100 kg.

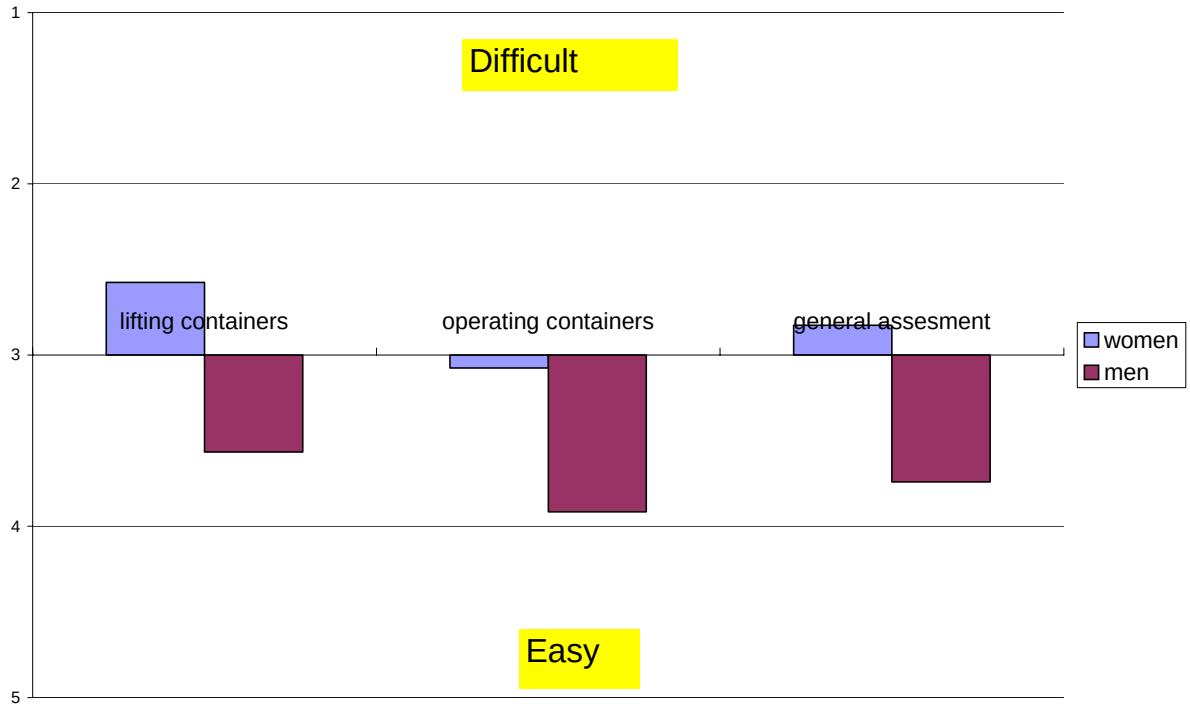


Chart 3 . Average assessments of difficulty of artificial fertilisers use by men and women in Poland.

Usefulness of Mobile Phone for Farming

Both in the two provinces in China and in Poland, gender is a relatively unimportant variable for the use of mobile phones in farming. In the Hubei province 93% of the men stated that they use mobile phones, while 90% of females stated that they use mobile phones. The corresponding shares for the Shandong province were 90% and 89% respectively. The relatively low impact of gender is also true in the Polish case, although

the usage is in general lower. 56% of the men in the Polish survey stated that they use mobile phones as did 55 % of the women. The largest difference between men and women was found in the Swedish survey. 75% of the males as compared to 66% of females in the Swedish results stated that they use mobile phones in farming.

The results of the Chinese surveys suggest a much wider use of mobile phones in farming among women in China as compared to women in Poland and Sweden. The estimated average assessments for both genders in both the Chinese provinces are above 3, i.e. users in general find mobile phones useful in farming. Also in the Polish case, the average assessment of the usefulness of mobile phones in farming is above 3, although (probably) not as highly rated as in the Chinese case. In the Swedish case users find three aspects of mobile use useful, plain speech, sending text messages and using voice mail, while the remaining categories receives results well under 3 (Chart 4). The average general assessment of usefulness of mobile phones (if all aspects are taken into account) was under 3 in the Swedish case.

What is noteworthy is that of all the aspects of mobile phone use that both genders in Sweden rated above 3, the rating among females of these three aspects was higher than the males. In Poland, the tendency that women find mobile phones more useful in farming than men in general was clearer. The Polish results suggest that women in general find mobile phones more useful than do men. General assessment of mobile phone usage in farming was not calculated for Chinese provinces.

One aspect that women rated as more useful than men for all surveys was sending text messages. One possible reason for this may be related to physical differences between genders at least as suggested by some comments from men participating in the Swedish survey. According to these comments, the mobile phone keypads were so small that it made them less comfortable to use for some men.

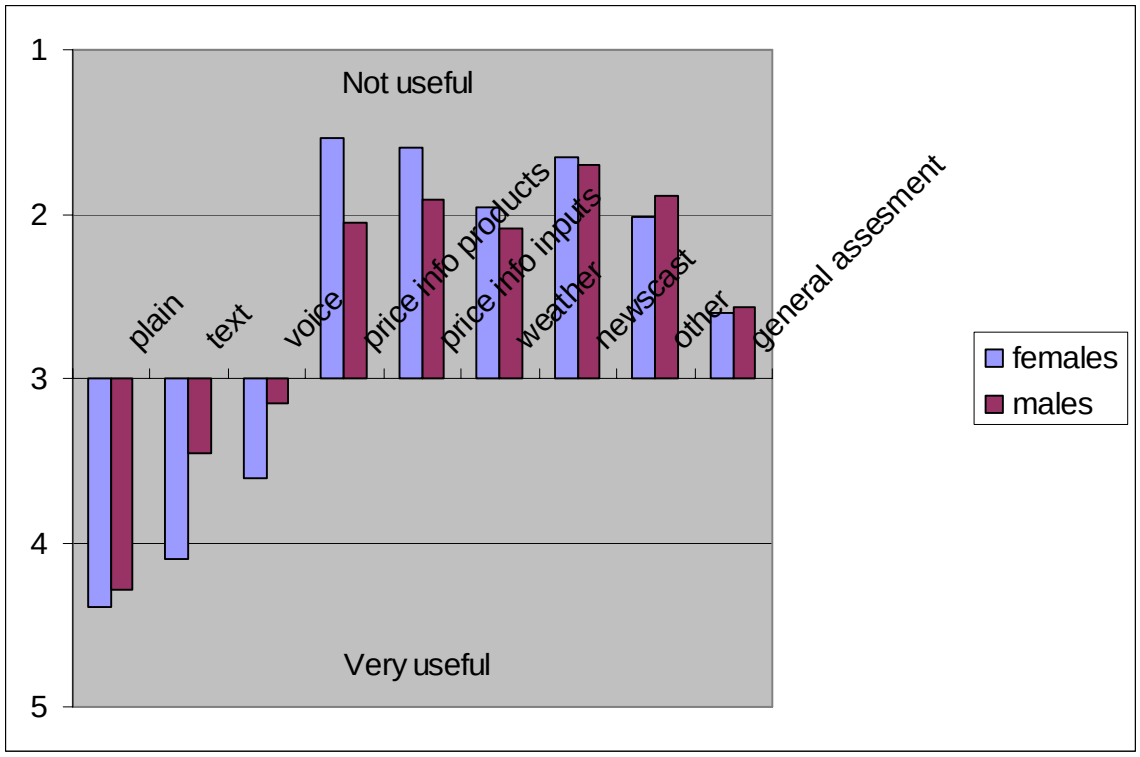


Chart 4. Average assessments of usefulness of mobile phone services by males and females in Sweden.

Sharing User Experiences

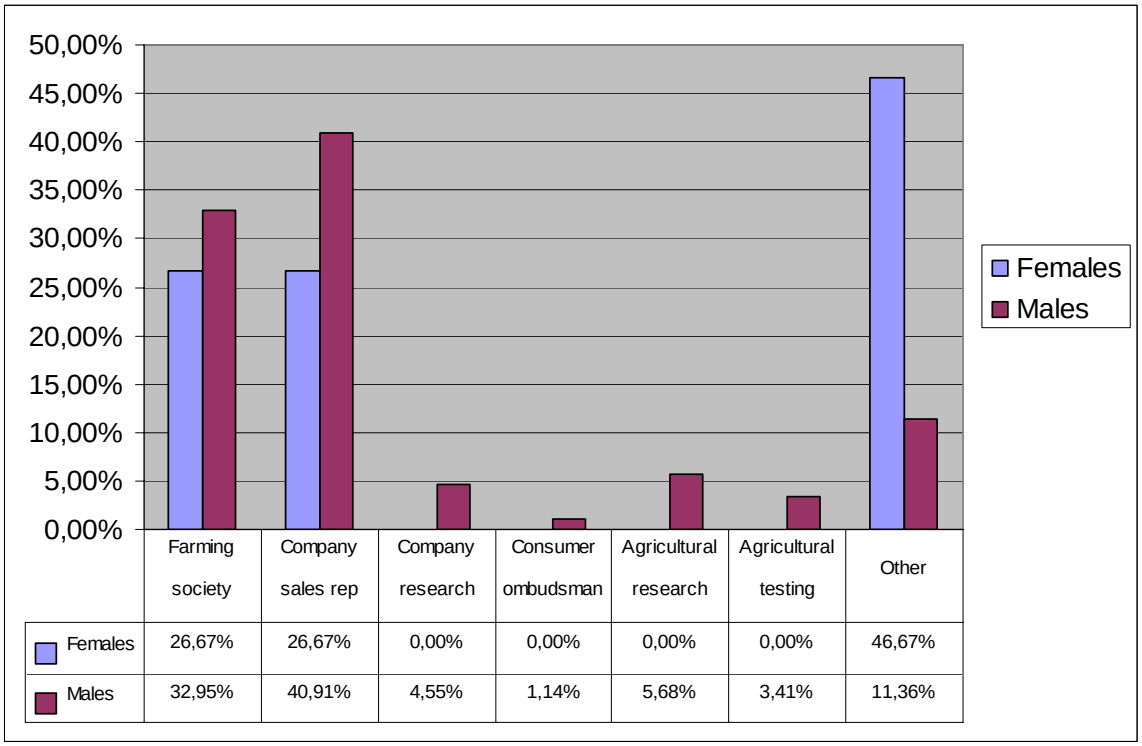
Included in the questionnaire were also questions concerning technology improvements and to what extent attempts had been made by users to communicate ideas to stakeholders. As was discussed above, the results suggest that Chinese users to much larger extent communicate user experiences to others, than in Poland and Sweden. In Sweden as few as 21% of males and 13% of females stated that they share user experiences with others.

With Swedish males being the exception, the most important category that users in all the three countries convey user experience to was 'other', i.e. family members, friends or neighbours. For Poland, more than 70% of females stated that they convey user experiences to family and friends. Although the Polish females stated that they address

also other categories, these were relatively less important. In China, more than 80% of the females in Hubei and over 90% in Shandong stated that they convey user experience to family and friends. In Sweden, of the few females who stated that they share user experience at all, 45% of the respondents stated that they convey user experiences to family and friends.

Other categories that are addressees for female user experience are company sales representatives and farming societies. Interaction with these categories is still relatively modest in comparison to the interaction that takes place with family members and friends. In the Chinese sample (both provinces), some 20% of females stated that they convey user experiences to farming societies while 18-20% of females stated that they convey user experiences to company sales representatives. Although Swedish females display higher shares of interaction with farming societies (27%) and company sales representatives (27%), the overall pattern is the same. In Poland, apart from family and friends females reported that they communicate user experiences to agricultural research setting (some 10-12%), farming societies (around 11%) and company sales representatives (around 10%).

The data gathered also provide some knowledge on what addressees are not utilised to convey user experiences among females. The general pattern is that females are not inclined to interact with categories most directly associated with research and development such as company research departments, agricultural research centres or testing stations. In the Swedish sample, 0% of females stated that they interact with those categories. In the Chinese sample, 0% of females stated that they convey user experiences to company research departments and agricultural research centres. In both Chinese provinces, less than 8% of the females reported interaction with consumer ombudsmen and agricultural testing stations. Among female respondents in Poland, some 11% reported interaction with agricultural research centres. Less than 5% of Polish females reported that they convey user experiences consumer ombudsmen and agricultural testing stations.



	Farming society	Company sales rep	Company research	Consumer ombudsman	Agricultural research	Agricultural testing	Other
Females	26,67%	26,67%	0,00%	0,00%	0,00%	0,00%	46,67%
Males	32,95%	40,91%	4,55%	1,14%	5,68%	3,41%	11,36%

Chart 5. Adressees of farmers's conveyance of user experiences in Sweden

Concluding remarks and recommendations

A systemic view of innovation renders some basic assertions of how innovation takes place. For instance, it is expected that the innovation system facilitates communication of user experiences back to the developers and suppliers of the technology. Such user experiences may be utilised by developers either as input for further research or adoptions of products to meet special user needs not initially known by the supplier. A well-performing innovation system would in that sense typically include some collection points which perform well in terms of collecting user experiences. If, on the other hand, the innovation system does not facilitate the communication of user experiences and user needs back to the developers one could argue that the innovation system underperforms on this account. In such a state, suppliers may run the risk of developing products that

does not meet market demand, and innovative idea coming from user experiences may be left unexplored and unexploited by suppliers.

In that sense, the survey presented here is an attempt to study the innovation system in terms of how efficiently it facilitates communication of user experience back to developers and suppliers. An initial step for such measurement would be to identify the components in the system that would potentially facilitate such communication of user experiences. In this case categories of components functioning as collecting points of user experiences included in the survey were for instance farming society, company sales representatives, and different kinds of research agencies. The entities may either be directly or indirectly capable of utilizing user experiences for further innovation. A rather unique feature of the survey is that it does not treat users as one homogenous group but takes into account gender.

To carry out a study on technology use distinguishing between genders might be pursued for more than purely academic reasons. As the results in the current survey actually suggest that there are differences in how males as compared to females perceive technology-use, further studies are justified. Furthermore, what makes the result even more interesting is the combination of the indications of gender differences in user perception in combination with the fact that women tend to communicate their user experiences to family members and friends, i.e. not to the system components more closely connected to research and development, such as sales representatives and R&D departments. In other words, there is a risk that user experience typically residing among females is not communicated to suppliers. This underperformance of the innovation system means that suppliers may miss out important knowledge that could be fed into further research and development or adoption of already existing products.

Taking into account women user needs become increasingly important as women increasingly are active on the labour market. Not the least in China, where the share of women workers in the agricultural sector is increasing, taking into account women user needs becomes crucial. It may then be argued then that the change of user categories in

the system (i.e. increased share of women interacting directly with technology) should be reflected by a change in the innovation system itself in order to maintain efficiency. The survey presented here suggests that there are some problems in the innovation system, in the sense that women user experiences may never get beyond evening dinner discussions with family and friends. The survey does however also provide a starting point for further improvement of the system, as it firstly, suggests that women user experiences do sometimes diverge from male user experiences and secondly; that women users do have user experiences that are communicated - although not necessary back to developers and suppliers.

Women represent a growing proportion of customers of everyday technology. They are more educated and are economically more independent than the women of previous generations, and could thus be expected become an increasing part of and target for specific product development. However, most inventions and techniques are part of larger technological systems which have evolved over time based predominantly on male norms and developed by male researchers. Innovating women-oriented products or service in such chains of interconnected products and services are difficult if the whole system is biased towards male needs and standards. Thus, women inventors may have to struggle against a technological system based on a male standard which keeps demand for piecemeal inventions low.

It may be, however, that technological progress in ICT in general and software development in particular has improved the possibilities for the articulation of demand for products geared towards women users. More flexible production systems, made possible by computer-based automation in manufacturing, and more generally the rapid diffusion of ICT may well come to serve the specific needs of end-users in general and women end-users in particular. User-design is a particularly robust form of participatory design that may have the potential to benefit from these general developments, and perhaps become instrumental regarding gender-specific design. The core issue in user-design is that end-users participate as equal partners in design, not only from the start of the actual project but also in the planning phase. Such participatory design concepts may

improve employment opportunities for women scientists as well as facilitate for women R&D personnel to respond to demand from women end-users.

The study indicates that women constitute an important innovation potential that is not fully utilized. Women are relatively poorly represented systems of innovation and learning, both as innovators and as articulators of end-user needs. The male perspective is still frequently the norm in technological R&D and the articulation of demand for new products is often a male prerogative. This implies a systemic under-utilization of the capacity for technological development and that there is an untapped innovation potential in the innovation system. Moreover, the study indicates that there indeed exist differences in preferences between genders and that the innovation systems have been slow or incapable of exploiting these differences with a consequent welfare loss to society.

How, then, can a more effective utilization of the untapped innovation potential represented by women scientists be brought about? Obviously, the roots of this particular phenomenon are buried deep within the same cultural, social and economic structures that define society at large. This complex situation makes it difficult to suggest policy recommendation, in particular recommendations for quick fixes.

However, there are some conclusions derived from the empirical data of our study that could be translated into policy at different levels. Starting with the micro level, it is clear from the questionnaire data as well as from the interviews that at least some segments of technologies indeed exhibit different demand patterns from women and men. It would seem that companies that recognize this could develop a competitive advantage over other, less gender sensitive, companies. Measures to exploit this niche could include:

- Creating incentive structures to encourage women researchers to become team leaders
- Setting up all-women, or women-dominated, development and design teams
- Include gender as an explicit group in user driven design
- Measures to make top management sensitive to gender-specific research
- Creating support teams or mentor programs for women researchers

These measures could also be employed at state funded research institutes and university research centers. It is clear that these institutions suffer from the gender imbalance in favour of men at higher research positions, despite the fact that women dominate university education as students a basic level. Activities to support women to attain higher positions are employed at most universities in the world today, but in many cases such affirmative action programs have not left any tangible results. As the processes behind this development are embedded in the university structure and usually not consciously recognised by faculty and staff, measures towards making these issues visible could also include:

Mandatory courses in gender issues for students and faculty

Entrepreneurship support explicitly geared towards women researchers

Support to intra- and inter-university women research organisations

On a national level, many governments are struggling with these issues on a broad basis. It is evident from the interviews conducted within the project that women researchers and, in particular, women inventors, often feel isolated and sometimes marginalized in their work. They benefit at several levels from getting opportunities to interact with other women in the same situation. Thus, encouraging the establishment of support structures for women researchers and women innovators could result in improved qualitative participation of women in technological development. On a national policy level, complementing general policies for the promotion of gender equality, national authorities could include the following measures in their policy portfolio:

Support to national networks for women researchers and inventors

Support to regional organisations for women entrepreneurship

These more concrete support actions must of course be complemented by long-term policy measures directed toward increased participation in science and technology. This includes working for changing attitudes towards women and scientific subject areas in school, higher education and in society at large. If a country is unsuccessful in fully including women in all aspects of S&T, the national innovation system - and the long term economic prospects, will not work at its full potential.

References

Gras-Velazquez, A., Joyce, A., and Debry, M., (2009). Women and ICT. Why are girls still not attracted to ICT studies and careers? White paper, European Schoolnet. http://www.orbicom.ca/index.php?option=com_content&task=view&id=1015&Itemid=202

Greenbaum Joan and Kyng Morten (Eds) (1991). Design at Work. Cooperative design of computer systems. Lawrence Erlbaum Associates. Hillsdale New Jersey. Hove and London.

Kline, Stephen J. and Rosenberg Nathan (1986). An Overview of Innovation. In R. Landau and N. Rosenberg (Eds), The positive sum strategy. Washington DC: national Academy Press.

Lundvall, Bengt-Åke (Ed) (1992). National systems of innovation: towards a theory of innovation and interactive learning. Pinter.

Prandelli, Emanuela, Sawhney, Mohanbir, Verona, Gianmario. (2008). Collaborating with Customers to Innovate. Conceiving and MAreketing Products in the Networking Age. Edward Elgar, Cheltenham UK, Northamption, MA, USA.

von Hippel, Eric (1988). The Sources of Innovation. Oxford University Press.