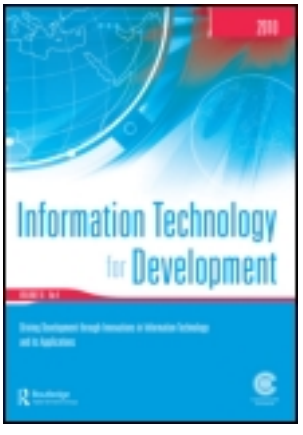

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Developing women: why technology can help

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Developing women: why technology can help

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The paper introduces a concept of household production technology that shows why Internet and communication technology (ICT) have the potential to increase the equity and efficiency of female participation in the labor force. Since inputs of female labor are required at short intervals in the production of the household good, female labor supply and earnings in the production of external goods fall below those of males. Household consumption at a point in time is maximized, but loss of potential learning-by-doing leads to dynamic inefficiencies, which power relations, bargaining, perceptions and self-perceived limitations reinforce. ICT helps restore flexibility in female external labor supply since it facilitates distance work, flexi-time and location activity, making it easier to match skills to jobs and to maintain and upgrade skills. But social structures and perceptions require intervention to become supportive. ICT has the potential to contribute to overall development for poorer women in less-developed regions of the world with appropriate policy.

JEL Codes: J16; O12; O33

Keywords: ICT; gender; learning-by-doing; matching; technology

1. Introduction

Gender issues have long been neglected in mainstream economics and in the framing of policy. The large gaps in women's work participation and earnings, especially in developing areas, require attention. South Asian women's share in employment is among the lowest in the world – 17.6% compared with the world average of 42 in 2004. South Asia, the Middle East and North Africa have the lowest female work participation. According to a 2007 survey, only about 13% of Indian women worked, and only a quarter had control over what they earned.[1] Sen (1985, 1999) has conceptualized development as acquisition of a vector of capabilities that enable many types of functionings. The first capability is economic and others include social opportunities, political liberties, trust and basic securities. The analysis in the paper shows that Internet and communication technology (ICT) is uniquely suited to help women acquire vital economic capabilities and functionings, but supporting social and political capabilities are required for the first to fructify and lead to overall development.

Economic research on the individual normally took the household as a unit. But research has begun to go beyond the household to derive its decisions from those of individual members and has shown that such a "collective" household maximizing individual utility functions would allocate resources efficiently (Chiappori, 1988, 1992). That is, allocation of labor time would be such

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as to maximize output available to the household. The underlying assumption, however, is that women have the same preferences and production technology for household goods as men.

But women allocate more time to the household, especially in a critical period in their career, so their productivity in the external market may fall, reducing their earnings compared with males. As learning-by-doing in remunerative skills falls, future wages fall as well. To model this, a production technology is specified in which inputs of female labor are required at short intervals in the production of the household good. Then, if she works more in the house, and the partner more outside, total household earnings rise. But, over time, this leads to a loss of her human capital. Thus an allocation of household resources that may be efficient at a point in time reduces the household's consumption set over time – creating dynamic inefficiencies. This consequence is missed in the standard collective household model. Perceptions and power magnify the distortions, at home and in the world. The paper demonstrates how a small difference in women's production technology can reduce their external labor input and wage profile over time, creating a gender gap. The key research question addressed, therefore, is the contribution of this concept of household production to understanding the potential of ICT for women, especially women in poorer countries.

Since the distortions originate with the household production function, ICTs have the potential to correct distortions at the source. They remove the disruption in the production technology since they facilitate distance work, flexi-time activity and reduce location constraints (Hafkin & Taggart, 2001). They also make it easier to match women's skill to jobs, and for women to maintain and upgrade skills. One consequence of the household technology is that women more frequently leave external jobs. A second model demonstrates how ICT can also reduce the probability of such separation and the adverse consequences following from that high probability.

But the original distortion generates others in perceptions, power and intra-household relations which unequal power affects. It is not only employers and patriarchs that have distorted perceptions; women also do in self-reinforcing traps. Gendered identity is a social construction (D'Mello, 2006; Gillard, Howcroft, Mitev, & Richardson, 2008) and can limit the utility of ICT. Modern ICT may have the potential to correct the source distortion, but its availability is just not enough. Changing perceptions and embedded social norms requires special policies. A rich set of case studies on ICT and development show bottom-up, context and culture sensitive policies have a better chance of success (Qureshi, 2005). Supportive social and institutional change is especially a prerequisite in regions where culture can exclude women from ICT (Elnaggar, 2008; Vodanovich, Urquhart, & Shakir, 2010), or the poor at the margins of society may find it difficult to access new technology (Cecchini & Scott, 2003; Sreekumar, 2007).

Models are useful to bring out clearly the consequences of initial conditions, which complex interacting conditions blur in the real world, as distortions get entrenched in a historical process playing out over time. The analysis in this paper implies women's use of ICT should increase despite the distortions, and would in time contribute to reducing the distortions. Full equality and decrease in the gender wage gap would, however, take longer, given the persistence of social structures and identities. Evidence on women's increasing use of ICT, in spite of initial fears of exclusion Huyer (2008), as well as evidence on persistent inequality (Hausmann, Tyson, & Zahidi, 2006; Pham Lobb, 2008) is consistent with the implications of the analysis. If a model succeeds in predicting emerging trends, it may be capturing fundamental driving forces.

Gould (1998) argues against what he calls the "pop science" view that behavioral differences between the sexes are due to biology. Thus men are said to lust after power, and women to enter the caring professions. Men are left brained and logical, women emotional, nurturing, people oriented. Although "differences in behavioral strategy do make Darwinian sense in the light of structural disparity between male and female reproduction" (p. 263), "what we share in

common genetics can easily overwhelm what men and women might tend to do differently" (p. 264). "At the very most, biology might help us to delimit the environmental circumstances that tend to elicit one behavior rather than the other" (p. 263). The analysis implies the gender wage gap may be due more to biology and its dynamic effects than to inherent behavioral differences. Productivity may not differ intrinsically. Therefore, technology or institutions that compensate for reproductive differences can allow human beings to specialize according to their deepest human capabilities, rather than on the basis of gender. Their choice set and freedoms expand (Sen, 1985). Research on global software organizations in India (D'Mello, 2006) finds traditional identities restrict the female workforce, but for the younger age group modernity moderates identities allowing young women and men to achieve both relatedness and autonomy, instead of women being restricted to the first and men to the second. It becomes possible to celebrate rather than stereotype differences (p. 154).

Before presenting the models, some relevant literature on gender, technology and development is surveyed. The models and their assumptions are discussed in relation to this literature and the methodology explained. Readers not interested in the models can skip Section 5 and the first three parts of Section 6.

The paper places itself in the relevant literature on gender and development in Section 2 and gender and ICT in Section 3. Section 4 clarifies the methodology to make it accessible to the non-technical reader, explaining key conceptual issues. Section 5 analyzes the effect of the household good's production technology: households' decisions in Section 5.1, firms' decision in Section 5.2, static market outcomes in Section 5.3. Section 6 examines how further inefficiencies set in: dynamics and learning-by-doing in Section 6.1, bargaining in Section 6.2, externalities and persistence (demonstrated in a simple search model) in Section 6.3. Distortions, including in power and perceptions, are put together in Section 6.4. Section 7 concludes by linking policy implications to the distortions. Some simple proofs are in the appendix.

2. Gender, technology and development

Initial technological developments did not help women as much as they were expected to. The literature on Women in Development (WID) has pointed out that modernization and the technological development that went with it initially raised the returns to work outside the home. As male bargaining power increased in the household, women's relative position deteriorated. Women's status was better in the past when they had a productive and not merely a reproductive role. Fisher (2003) collates evidence that the agricultural revolution made male roles more important than female roles, changing conditions that had prevailed for millions of years, when women worked and brought home 60–80% of the evening meal. Their relative position was almost equal to that of men. Boserup (1970) also argues that in the colonial period, when males were recruited for plantations, etc., women were pushed to subsistence production, which kept the supply of males cheap but worsened the position of women. The inference was that the differences between the sexes arose from differing work experiences. So with professional training women could be as productive as men in the external world. But instead the development process marginalized women. New resources, experience and opportunities largely went to men. This experience inspired the initial modernizing feminist position that women in order to develop must become more like men.

But the WID perspective neglects values essential for a well-rounded humanity, contributing inadvertently to the subtle liberal devaluing of "women's work." It is beginning to be recognized that development will be fully successful only if it is gender aware and both sexes change; men contribute more to nurture while women become more active outside the home. The modern gender and development (GAD) and ICT for development (ICT4D) approaches, therefore,

doubt if modernization alone will automatically improve women's position without institution and culture sensitive programs.

Since ICT corrects the original distortion in production technology it allows women to gain economic independence and status without imitating men. ICT will have enabled a technological U-turn if technology is able to help women more in its later stages than it did in the earlier ones (Goyal, 2007b). But as both the GAD and ICT4D approaches point out, gender sensitive policy is required for the full benefits to occur.[2] Changes will take time since they have to battle entrenched prejudices, whether those of women or their employers.

All women share the biological constraints and historical disadvantages and can gain from the flexibility ICT makes possible. But income inequalities, social restrictions and urban–rural divides, especially in less-developed regions, compound gender differences. Policy implications therefore also have to take these differences into account. While urban women, and women in mature economies, would benefit from cheap broadband connections, rural women and low-income women would require telecenters, cyber cafes, awareness and training in the business opportunities they generate. In general, social, political and economic factors restrict spillovers from technology to the poor, and must also be addressed. Cecchini and Scott (2003) show how slower progress in techniques used by the poor can increase divides. Sreekumar (2007) assesses an Indian e-governance project as embedded in and reinforcing local power relations. Ignoring the social shaping aspect, compounded with backwardness and official lethargy, reduced gains to the poor. Social processes at the ground level must be understood and harnessed for effective development. Policy must target institutions as well as broad macroeconomic factors, keeping people's needs in mind (Qureshi, 2005).

3. Gender and ICT

The failure of modernization to substantially improve women's position has contributed to a deep ambivalence in women's relation with technology. The women's movement recognizes the importance of ICT, and the necessity of using the opportunity, but it is feared that women may either be left behind or it will further burden them. The reasons for the first are that women have less online access than men do because they have less time, money, control, learning opportunities and more commitments in the household. Second, distance working may imply a double burden, of home and of outside work. Home working may isolate them, forcing them to accept lower wages and poor working conditions. There is evidence that women themselves prefer to work outside but near the home (Hafkin, 2008). Technology can make them non-stop workers, instead of improving their options. Unequal power dynamics built into gender relations can imply an ICT enabled feminization of the work force, with cheap labor supporting capitalist profitability and globalization (Gillard et al., 2008). Gender bias, inequality and misperceptions that women can do only limited types of work and are technologically inept, must first be removed for women to be able to reap the full potential benefits of the new technologies. Otherwise existing digital divides are feared to worsen (Hafkin & Taggart, 2001; Woodfield, 2000). Women are often clustered at the low end in low-skill and low-pay IT jobs such as data entry, with limited representation in managerial and technical positions. But even these jobs improve opportunities for women in poor countries.

Wages are low partly because outsourcing increases the virtual labor supply, but it does bring hitherto excluded categories into the market and is a first step in the development process. Although rising labor supply should decrease wages, there is some evidence it induces favorable technological change thus raising productivity and wages (Goyal, 2007a). ICT makes more options available, such as part-time outsourcing work, flexi-time work, entrepreneurship and marketing or skill upgradation. But having the ability to do more does not imply one has to

do more. It only means that it becomes easier to match activities to preferences, thus improving effectiveness and welfare.

Keys to delivering more freedoms and control of their lives are to raise the level of skills, create supportive organizations and local content, improve exit options and generate awareness. With the superior economic status and bargaining power it gives, ICT should gradually enable women to negotiate more equal sharing of homework.[3] It can allow both men and women the freedom to participate in care and nurture while maintaining active professional lives. It enables participation in the knowledge-based economy of the future. Being at the technological frontier becomes compatible, for women, with more presence in the household. Active and purposive social networks outside the house do contribute more to women's independence. But ICT does make many such networks feasible even with home-based work. Many task or interest oriented websites make networking easier. It is also easier to get information about and entry into such networks.

These natural advantages can be expected to contend with the blocks identified in women's participation in ICT. The evidence does show increasing participation. But greater political agency be may the key to short-circuiting the process and attacking persistent inequalities, as argued in the concluding section of the paper.

4. Methodology

A model allows one to set up a laboratory, not otherwise available in the social sciences, where conclusions follow from premises and structure. A model is never literally true, but can help to identify causal chains that are otherwise hidden in complex interactions. Assumptions made should be adapted to context, but are also not literally true because they are abstractions. The real contributions of a model are the non-obvious insights into a process, or the testable predictions it generates. There was a famous debate in economics on methodology with Milton Friedman taking the instrumental position that the better model was one where simpler or less realistic assumptions generated better predictions. Samuelson's position of operationalism required more realistic assumptions so that theories were articulated in observable and measurable variables. But both agreed, since theories were about prediction not description, assumptions had to be simplified and the test for theories was precise predictions that were not falsified by evidence (Boland, 2008). The specific form of the household production function assumed in this paper, takes the assumptions of the collective household model closer to reality. This small change upsets the efficiency results of that model, giving more precise predictions about the impact on women's human capital and the utility of ICT.

Economics studies efficiency. That is, putting scare resources to the best use to get the most for the least. An outcome is defined to be Pareto efficient if it is not possible to make someone better off without making someone else worse off.[4] The collective household model is in this tradition of economics and shows how resources are organized to yield efficient outcomes, even though the production of the household good is out of the market.

Individuals supply labor in complex systems of production to produce goods consuming which gives them utility. The process by which labor is combined with other inputs to give output is known as a production function. In a household, the male and female pair each has a fixed number of hours, which they choose to distribute between leisure, the production of household and of external goods. Leisure has to be foregone to produce the goods and all three types give utility according to a preference or utility function that is assumed to be the same for the male and the female. Productivity in external work, and wages received, determine household external consumption possibilities.

The power of these models comes from the marginal conditions, the adding up conditions, and interactions across markets. Marginal conditions adjust choices to relative prices. For example, the utility from an extra unit of effort in external good production (the consumption wages make possible) must at the margin equal the disutility from the additional labor input required. For example, if disutility from labor were lower, it would be possible to increase total utility by increasing labor input. The gain in utility from the additional consumption would exceed the loss from working harder.

The adding up condition is that aggregate demand must equal supply. Totaling labor inputs across households gives the total labor supply in the market. Labor demand comes from firms that produce the external consumption good households' buy. Wages adjust to equate demand to supply, and this labor market clearing determines the level of wages. Since firms are actually an intermediary, they can be treated as owned by households. They organize production, using labor inputs from households to produce optimal amounts of the external goods the household consumes. Any profits they earn in the process are distributed to households as the ultimate owners of the firms. If firms were perfectly competitive, equilibrium profits would be zero. In the simplest models, it is possible to dispense with firms altogether, and work with producer–consumer households. This is general equilibrium because demand supply equalities must hold in all the constituent markets.[5]

Thus demand must equal supply for the external good also, and this market clearing determines its price, and affects firms' revenues and the wages they are able to pay. The markets are linked. The wage rate affects demand for the good, and therefore its price. Theorems in economics establish smooth mathematical properties for the production and preference functions under which simultaneous market clearing equilibria would hold. These assumptions are not satisfied in real world markets, and many other types of frictions imply that disequilibria and waste should rather be most frequently observed. But simple models provide a benchmark, which help to identify useful structures and tendencies, and into which different types of frictions can be systematically introduced.

In collective household models, apart from the disaggregation within the household, a new element is the household good, which is a special type of good. It is a non-marketable good. Since the consumption of one spouse does not reduce that of the other it is known as a public good. But the cost of production of the household good will depend on the opportunity cost of time for each spouse. The assumption of female input supply at fixed intervals adds some rigidity in the production of the household good, lowering the flexibility of female external labor supply.

Such a stylization follows from biological requirements of childbirth and raising small children. Even if this period occupies a small part of a woman's life, it often coincides with a period vital for developing a conventional career. Empirical support comes from studies such as Layard, Barton and Zabalza (1980) who report that in Great Britain a child under 3 years of age lowers female labor force participation by 65%, and hours worked by 1000 per year. Sanchez and Pagan (2000) have similar results for a study of rural Mexico, where women tend to specialize in non-market activities after marriage. Only 20% of married women reported being employed, and the number of young children decreases the probability of employment.

The production function specified implies that supply and demand for female labor in the production of the external good is less than for male labor. This static outcome is efficient, in the sense it gives the household the largest set of, total even if unequally distributed, consumption possibilities. Wages may or may not be the same, but female earnings are lower. If there is more learning-by-doing in the private good production, female human capital falls and male wage rises relative to female. Over time, women's low-wage work leads to a cumulative loss in their human capital in a self-reinforcing low-level trap. Power-relations, self-confirming perceptions and changes in bargaining ability multiply distortions in both the demand for and supply of women's labor. Despite static efficiency, considerable dynamic inefficiencies occur

– outcomes are unequal and not even Pareto optimal. The unequal labor supply decisions can be sustained if under reciprocal altruism the household compensates women for their lower wages. But asymmetric power often degenerates into bargaining modes, pushing women to their reservation, or lowest acceptable level of utility.

Another implication of these types of rigidities is that women tend to give up their external jobs more frequently than men – that is "separation" from a job match is higher for women. Our second model of matching jobs to workers, with a higher probability of separation for women, is a co-ordination failure model building on the concept of externalities. The latter is an important type of friction neglected in the first simple model of markets. In market equilibria based on individual maximization an agent does not take into account how her actions affect another. If these effects are large her actions can then differ from the social optimal. For example, if a factory does not internalize the pollution it causes, production would be larger than optimal. Externalities are one reason why markets can fail and government interventions, such as pollution taxes, are required. Externalities can also cause low- and high-level equilibria. A coordination failure can then occur, where an action with positive spillovers for others is not done. The outcome is at the low level, so everyone is worse off.

In the model, firms' need to hire a new worker after a worker is separated from a job. They are more likely to invest in high technology, if new workers they hire have the relevant skills. But workers are more likely to acquire these skills, if firms have invested in technology making the skills relevant. Therefore multiple equilibria become possible, with a low and a high level of investment in skills and technology. ICT lowers the probability of job separation for women toward that for men. It increases women's inducement to train and update their skills, and for firms to invest in them. It makes firms' investment in new technology more likely, thus creating positive externalities for other firms. The probability of the outcome jumping from the low to the high level rises. Innovation and training are self-reinforcing – subsidizing these raises the probability of the better outcome further.

5. The collective household with rigidities in women's labor supply

5.1 *Household decisions*

With the rigidities in the labor allocation for the household good, male external labor supply exceeds female. This maximizes the household's total utility at a point in time but not over time. Consider a two-member household $i \in \{F, M\}$. The total time available to each member in 1 day is T. If L^i is the consumption of leisure and $l^i{}_B$ labor supplied for the household good, B, then each supplies external labor, l^i:

$$l^i = T - L^i - l^i_B. \tag{1}$$

There are q households with identical non-labor income, y, and one male and one female each. The price of the external good, X, is normalized at one. Production of X equals aggregate consumption, qC, in equilibrium. The non-marketable household good is a public good since consumption by one spouse does not reduce the amount available to the other,

$$B = B^{\mathrm{F}} = B^{\mathrm{M}},$$

and its price, derived below, would be the same for both household members:

$$p = p^{\mathrm{F}} = p^{\mathrm{M}}.$$

Production of B within the household requires labor from both members, but female labor inputs are required at four-hourly intervals throughout the day.[6]

$$B = f_B(l_B^{\mathrm{F}}) + m_B(l_B^{\mathrm{M}}), \tag{2}$$

$$l_B^{\mathrm{F}} = l_{B1}^{\mathrm{F}} + l_{B4}^{\mathrm{F}} + \cdots + l_{B16}^{\mathrm{F}}. \tag{3}$$

The production function (2) is smooth, well behaved, and twice differentiable. These assumptions ensure that some of each input will be used. Production of the household good requires the use of male and female labor in two separable activities $m_B(.)$ and $f_B(.)$ respectively. This additive separability implies that the marginal product of one input is independent of the other input. Periodic input (3) of female labor in the production of the household good implies that $f_B{}' > m_B{}'$ for all l_B, where derivatives are indicated by a superscript dash. That is, the female marginal product curve always lies above that of the male.

There is a labor market for the production of the private good where wage w^i is paid equal to the daily marginal product of each member. The household faces a budget constraint: both member's consumption of the two goods and of leisure must be less than or equal to their potential earnings plus non-labor income. The utility of member i is:

$$U^i = U^i(B, C^i, L^i),$$

where U^i takes the quasi-linear form $U^i = u^i(B, L^i) + C^i$ since this allows a focus on the effect of relative wages. The labor supply decisions allocate labor between the household and external good, and across members, such that marginal productivities are equated between activities for each member, and they equal exogenously given market wages. Since $f_B{}' > m_B{}'$ for all l_B in equilibrium

$$l_B^{\mathrm{F}} > l_B^{\mathrm{M}}.$$

Ceteris paribus the external labor supply of each household member will be an upward sloping function of own wage rate. But because of the technology of production of the household good, females can offer only interrupted labor supply. This increases their transaction costs and the opportunity cost in terms of leisure. Therefore, the female labor supply curve will lie to the left of the male. Multiplying individual labor supply curves by q gives the aggregate supply curves (Figure 1):

$$S^{\mathrm{F}} = ql^{\mathrm{F}}(w^{\mathrm{F}}, w^{\mathrm{M}}),$$

$$S^{\mathrm{M}} = ql^{\mathrm{M}}(w^{\mathrm{F}}, w^{\mathrm{M}}). \tag{4}$$

Next aggregate demand curves are derived from the decisions of firms, and used to derive the static equilibrium, which depends on both demand and supply.

5.2 *Decisions of firms*

If the organization of production is such that the productivity of uninterrupted labor supply exceeds that of labor applied in bursts, the marginal productivity of equal female labor time in the production of the composite private good, X, will be lower than that of male. The

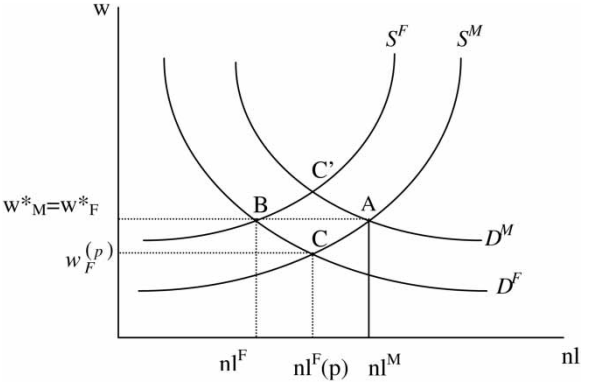

Figure 1. Relative male and female external labor supplies under equal wages.

aggregate demand for female labor will lie below that of male (Figure 1). This is derived below. There are n identical firms. Each firm j's production function is:

$$X_J = f(l^{\mathrm{F}}) + m(l^{\mathrm{M}}), \tag{5}$$

where X_J is the good produced by the jth firm; the production function is smooth concave and well-behaved ensuring that some of each input will be used. Production requires the use of male and female labor in two separable activities m(.) and f(.) respectively.[7] Separability implies the marginal product of one input is independent of the other input.

The firm takes wages as given and maximizes profits, or revenue minus costs:

$$\max_{l^{\mathrm{F}}, l^{M}} f\left(l^{\mathrm{F}}\right) + m\left(l^{\mathrm{M}}\right) - l^{\mathrm{F}} w^{\mathrm{F}} - l^{\mathrm{M}} w^{\mathrm{M}}. \tag{6}$$

It maximizes profits when the respective wages are equated to the marginal products, that is, output produced by employing one more unit of labor equals the wages paid to that labor.

$$f'(l^{\mathrm{F}}) = w^{\mathrm{F}},$$

$$m'(l^{\mathrm{M}}) = w^{\mathrm{M}}. \tag{7}$$

The firm is a wage taker. If Equation (7) is satisfied, it is indifferent between employing male or female labor. Aggregate demand, D for the two types of labor is n times the individual firm's demand, and is obtained by solving:

$$\begin{aligned} f'\left(\frac{D^{\mathrm{F}}}{n}\right) &= w^{\mathrm{F}}, \\ m'\left(\frac{D^{\mathrm{M}}}{n}\right) &= w^{\mathrm{M}}. \end{aligned} \tag{8}$$

5.3 *Static equilibrium*

The labor market equilibrium determines a pair of wages $\{w^{F*}, w^{M*}\}$ such that demand for each labor category and for aggregate labor equals supply:

$$D^{F}(w^{F}*) = S^{F}(w^{F}*, w^{M}*),$$

$$D^{M}(w^{M}*) = S^{M}(w^{F}*, w^{M}*), \tag{9}$$

$$D^{F}(w^{*}) + D^{M}(w^{*}) = S^{F}(w^{*}) + S^{M}(w^{*}).$$

Any profits made by firms are distributed to households as non-labor income, y. Separability ensures both demand for and supply of the external labor of one household member is independent of that of the other, but they do depend on the other's equilibrium wages. Our assumptions on the production technology imply that both types of labor are necessary for production, but at equal supply, female labor is less productive than male labor in the production of the private good, but more in the household good's production.

The collective household and firm decision models imply that in an efficient allocation of labor, (i) female labor supply, in the production of the private good, is less than the male labor supply, but (ii) the demand for female labor is also lower. It follows that, in a static equilibrium male and female wages will be equal: $w^{M} = w^{F} = w^{*}$. If not, and $w^{M} > w^{F}$, the household can increase its consumption of the external good without decreasing its production of the household good if the females reduce external labor supply and increase labor supply in the production of the household good. The opposite adjustment occurs in male relative internal and external labor supplies. This explains the positions of the curves in Figure 1 and the equilibria A and B.

The technology of production of the household good affects both labor supply and demand. Supply compensates for differences in demand such that total household consumption is not affected. But although women have the same wages in equilibrium they work less outside therefore their total earnings, $w^{*}l^{F}$, are lower.

6. Inefficiencies

6.1 *Dynamics and learning by doing*

If there is learning by doing, current own productivity depends on all past own labor inputs. This is modeled in Equations (10). Dropping the male–female superscripts to save on notation, and putting more structure on the f and m functions, they become:

$$f = l_{t}^{\alpha}\left(\sum_{t=1}^{T-1} l_{t}\right)^{\eta},$$

$$m = l_{t}^{\beta}\left(\sum_{t=1}^{T-1} l_{t}\right)^{\gamma}. \tag{10}$$

The smooth concavity assumptions made in Equation (5) continue to be satisfied if $\alpha + \eta < 1$ and $\beta + \gamma < 1$. Assuming, as a simplification, that the number of labor hours worked were the same every day in the past, and R refers to the total days worked, the summation in Equation (10)

will come to $R_F l^F$ and $R_M l^M$, respectively. Since l^F is less than l^M, $R_F l^F$ will be less than $R_M l^M$. Moreover, the interrupted female labor supply implies $\beta + \gamma > \alpha + \eta$.

We assume that learning-by-doing and rise in productivity in private goods production exceeds that in household public good production. Both static productivity and learning externalities are lower for females. Therefore, in Figure 2, $D^{F'}$ lies below $D^{M'}$. Superscript dashes distinguish dynamic functions and variables from static ones. As learning accumulates the gap keeps widening. The firm's optimal conditions (7) now change to:

$$f'(.) = w^{F'} = \alpha l^{\alpha+\eta-1} R_F^{\eta},$$
$$m'(.) = w^{M'} = \beta R_M^{\gamma} l^{\beta+\gamma-1}.$$

The rise in demand for male labor will be greater than any rise in male labor supply, so that $w^{M*'}$will tend to rise. This will lead to adjustment in male/female labor allocation, since each member's labor supply is also affected by the other's wage. Male labor supply in the production of the private good will rise, and that of females will fall.

A large relative rise in demand for male labor, or a fall in demand for female labor that is greater than the fall in female labor supply, will be sufficient to ensure that at $w^{M*'}$, $D^F(w^F)' < S^F(w^F, w^M)'$, so that $w^{F'}$ will fall, and in the new equilibrium, $w^{F*'} < w^{M*'}$. Now not only is female labor supply in the production of the external good lower than male labor supply, but equilibrium female wages will also be below male wages.

If learning by doing is so high that $\beta + \gamma = 1$ then the $D^{M'}$ curve will be horizontal, and shift up over time. Equilibrium would still be determinate,[8] since the firm's optimal marginal conditions are concave for fixed values of the externality causing parameters. Doing the first order derivation and then substituting for the externality in terms of the endogenous variables l gives a determinate labor demand. But now equilibrium female wages can never equal male wages. Potential household earnings fall.

Even forward-looking households cannot adjust their static labor allocation decisions to achieve dynamic efficiency, because they are unable to postpone inputs into child-rearing. Our model captures this by imposing a very high marginal utility for small values of consumption of B. The household ignores the resulting dynamic inefficiency, in making static labor allocations, if its rate of discount is high or more importantly, nonlinear.[9] Our results go through as

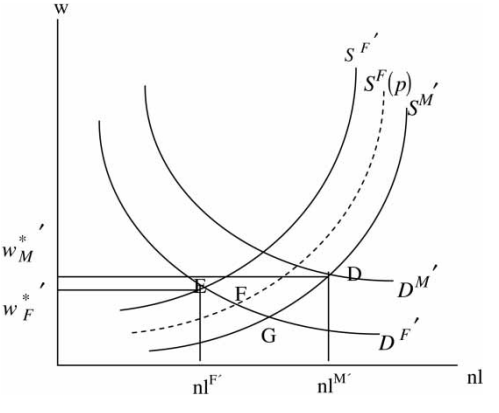

Figure 2. Equilibrium with unequal wages.

long as there is a critical period in the early life of a household where the production of the public good, with the particular technology, is binding.

6.2 *Preferences, bargaining and welfare*

If the preferences of household members are caring, income transfers to the female could compensate for her lower earnings so that there is equity in consumption and leisure. The collective household approach is well suited to analyzing such transfers. The optimization can also be expressed equivalently in terms of a rule sharing non-labor income between the two members. This has a useful interpretation as the outcome of the process that internally distributes the efficiently created household income. Once efficiency considerations have determined labor supply, transfers can ensure equitable female and male consumption.

The collective approach is equivalent to the neoclassical approach where a welfare function of the form $W[U^{F}(\cdot), U^{M}(.)]$ is maximized subject to constraints. Chiappori (1988, 1992) shows that such a "collective" household maximizing individual utility functions, a "neoclassical" household maximizing a common utility function, but with separable utility, and a "bargaining" household would all allocate resources efficiently when consumption and labor supply decisions are derived from household utility maximization. These results also apply using our technology of household production.

Since individual utility functions are maximized in the collective approach it can handle egoistic preferences, where each member is concerned only with own leisure and consumption. But altruistic preferences can also be accommodated. Member i would then maximize $W^{i}[.,.]$ that depends on both utilities. The Pareto efficient decisions of altruistic agents are a connected subset of the Pareto frontier derived from egoistic preferences, since if it were possible to increase U^{F} without decreasing U^{M} it would not be maximizing W^{i}. The opposite extreme from the altruistic preference is the dictatorial preference. If low exit options for women, plus egoistic preferences, give the male member dictatorial power, then he would maximize his utility, subject to offering the other her reservation utility. These power relations would imply a low share for the female. Labor supply and consumption demands would be functions of the earlier variables, but with the male share maximized.

Under bargaining, the distribution between the members of a household would be determined by relative bargaining power. Utility at the threat or disagreement point[10] must equal the reservation level. This is the minimum level of welfare the agent can obtain if no agreement is reached. Since any solution is Pareto efficient it is a particular case of the earlier solution. Dynamic inefficiency would imply that the utility frontier shifts in over time, or expands at a rate below potential. If bargaining determines household allocation, then a rise in female wages would raise her bargaining power and therefore her share in non-labor income. Such a rise would also reduce dynamic inefficiency.

We have traced differences in work and wages to the household production technology, although such outcomes are more often traced to differences in preferences.

6.3 *Reinforcement and persistence mechanisms*

A simple search cost and coordination failure model[11] for labor markets differentiated by gender shows why adverse outcomes can persist, and the potential contributions of ICT in reducing this persistence and instead creating positive self-reinforcing mechanisms.

This is a model of matching workers to jobs, where the trio maximizes joint surplus, not a flow model where wages are equal to outside options. Wages are not determined by flow supply and demand, because of the search costs. There are a large number of firms and an

equal number of households. Each firm employs one male and one female worker. There are two periods. In the pre-market period a firm may invest in ICT technology and a worker may train to increase human capital (h). The total cost of training and innovation is $T = \varsigma\tau + h_{\mathrm{F}} + h_{\mathrm{M}}$, where $\varsigma = 1$ if the firm invests in technology and is zero otherwise, and each sex chooses its level of training from a set $[0, \tilde{h}]$. Since the result depends on the combined surplus (CS), it does not matter if the firm or the worker incurs the cost of training. It is assumed there are no credit constraints, the firm and the worker can write complete contracts, and the worker can make a transfer payment to the firm.

At the end of the first period, a match specific shock occurs and there is a probability s of the worker separating from the job. That is, the worker and the firm are no longer matched. This probability is s_{F} for the female worker and s_{M} for the male worker. The household good production function implies[12] $s_{\mathrm{F}} > s_{\mathrm{M}}$. Output is produced in the second period. If trained workers are matched with a firm that has adopted ICT, so that both training and innovation are available together, productivity rises by $q(h)$. There are diminishing returns to scale, so productivity increases with labor input, but at a decreasing rate: $q'(\cdot) > 0, q'' < 0$. Technology costs and the q function are identical for male and female workers. For a trio making investment decisions in the pre-market period, the probability of a good match is f ($0 \leq f \leq 1$), which is the proportion of firms who have adopted the new technology (equal to proportion of trained workers). After parting, if there is a mismatch, the rise in productivity is not attained. If the interest rate is r the combined return to the period one investment decision of the trio is CS:

$$CS = q(h_{\mathrm{F}})(1 - s_{\mathrm{F}}) + q(h_{\mathrm{F}})fs_{\mathrm{F}} - h_{\mathrm{F}}(1 + r) + q(h_{\mathrm{M}})(1 - p_{\mathrm{M}}) + q(h_{\mathrm{M}})fs_{\mathrm{M}} - h_{\mathrm{M}}(1 + r) - \tau(1 + r).$$

CS is returns minus costs arising from hiring male and female workers. In pairs where separation occurs, only the proportion f earns q. If $f = 1$ or all firms innovate and all workers train, the s terms cancel out. By deriving optimal h^* from CS, when $f = 0$ and when $f = 1$, the appendix proves that:

LEMMA 1 *If all firms invest in ICT male and female training levels will be equal, if not male training levels will exceed female.*

If investment is productive so that $q(h) > (h + \varsigma\tau)\ (1 + r)$ both $f = 1$ and $f = 0$ could be equilibria, where production is feasible. In the potential co-ordination failure where $f = 0$, firms do not invest and workers do not train. Figure 3 shows the gross return (GR) and cost (C) curves and how they change as f rises. The appendix proves Lemma 2 by deriving the shape of these curves, and showing they must intersect.

LEMMA 2 *There exists a critical or threshold level of $f = f_c$ above which all firms will invest.*

At the intersection point GR $= C$. This gives the critical or threshold level of $f = f_c$. Above f_c all firms will invest since gross returns exceed cost, and below f_c no investment will be undertaken.

LEMMA 3 ICT decreases s, as s falls f_c also falls. As s falls to zero, all firms invest.

Proof. By facilitating distance work ICT lowers the probability of separation after a match specific shock. It also lowers the transaction costs of finding a new match. For positive s ($0 < s < 1$), a fall in s shifts the two curves upwards, with the GR curve rising more than the C curve as the dashed curves in Figure 3 illustrate. Hence the new f_c is lower at f_c'; implying a smaller rise in investment is required to cross the threshold leading to a cumulative rise in investment. As $s_{\mathrm{F}} \to s_{\mathrm{M}} \to 0$, C_0 shifts up to C_1 and GR_0 to GR_1, so that all firms will invest and $f \to 1$.

Since ICT compensates for the rigidities in the female production function for the household good, it lowers s_{F} more than s_{M}. As $s_{\mathrm{F}} \to s_{\mathrm{M}}$ the optimal levels of female training rise and

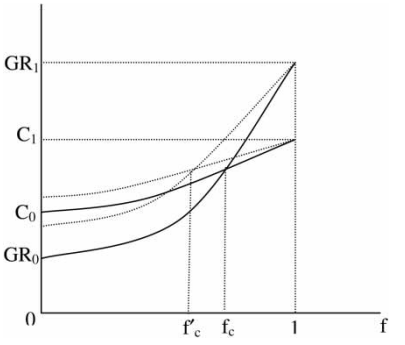

Figure 3. The effect of a fall in separation probabilities.

approach male levels. Since, barring family concerns, women tend to be more stable at work, ICT may reduce s_F below s_M. Then training of women may even exceed that of men at $f < 1$. As all firms invest, female and male training becomes equal. Since ICT decreases s it is possible to break out of low-level traps into a self-reinforcing virtuous cycle.

6.4 *Distortions*

The technology of household production culminates in the distortions surveyed in the subsections above. Although itself compatible with the efficient static allocation of household resources, the others cumulate into severe dynamic inefficiencies and wastage of potential human resources. The household's future consumption possibility set falls. The equilibria derived above are used to classify each distortion, and implications are drawn for the household's welfare.

Result 1 Equilibria *A* and *B* constitute an efficient static labor market outcome. The household's income is at its static maximum. Female wages are the same as male but earnings are lower.

If wages are equal marginal productivities are equalized across activities and household members. The female member works more at home and less outside (at *B* in Figure 1); the male member works more outside (at *A*), so her external labor time and earnings are lower. This is the basic distortion due to the technology of household good production. But static outcomes are efficient, since the household cannot get more from its resources.

Result 2 Employer's perceptions or power induce the inefficient static equilibrium C or C'.

Now consider a household whose consumption of the public good *B* is low so that the external female supply curve coincides with the male curve. But if equilibria such as *A* and *B* dominate, employers may lack the information to discriminate between the two female labor types or have the misperception that female productivity is lower and will offer all females only the wage, employment pairs on the curve D^F (Figure 1). Although f' may not lie below m' (Equation (7)) the first-order condition for the firm is $f'(l^F) - d = w^F$, where $d > 0$ measures misperceptions or power. Then the female would have to accept a lower wage, at the perception equilibrium *C*. Since the male will work more outside, for the household to benefit from his higher wage, she will have to work more at home. Labor allocation will be inefficient.

Social norms may give employers the power to offer lower wages to females.[13] Since the female has no alternative even if her marginal productivity is equivalent to the male along D^M and the employer knows it, he can extract the excess of female marginal productivity over the wage he offers her. This surplus equals the gap between the two demand curves. If

her supply curve coincides with the male at *C* the gap would be *CC*'. Since the *AB* equilibrium Pareto dominates *AC* for the normal household, *C* will not generally be observed. The household will prefer to stick to the traditional household technology and roles, so that even a rational and far-seeing household would incur dynamic inefficiencies.

Result 3. Decay of female human capital induces the dynamically inefficient equilibrium ED.

But equilibrium *AB* is unlikely to persist. If the productivity gap between male and female labor rises because of learning by doing, and there is a minimum bound to their input in the production of the household good, the representative male can run into the time limit *T*, before his marginal productivity falls to equal that of the female. If D^{M} is nearly horizontal and lies everywhere above the D^{F} the two productivities cannot be equated. Then an equilibrium pair such as ED will be observed (Figure 2). In equilibrium female wages are now lower than male. Females work less outside and have a much larger share in the production of the household good with a commensurate fall in earnings.[14] ED shows dynamic inefficiency since there is a loss of potential female productivity. The household consumption possibility set grows at less than potential over time.

Result 4 Female perceptions or employer perceptions or power, induce dynamically inefficient equilibria *F* or *G*.

Perceptions or employers use of power can reinforce the dynamic inefficiencies. If damaging perceptions come to be shared by women themselves, they could be willing to work at lower wages so that the supply curve shifts out to $S^{F}(P)$ or even equal to the male supply curve (Figure 2), as women sacrifice leisure. The female's utility function becomes $U^{i} = u^{i}$ $(B, (L^{i} - h)) + C^{i}$, where she is willing to give up h hours of leisure, some for external work. Now she would be working longer hours outside at lower wages, and putting in a larger share in the production of the household good, at equilibria such as *F* or *G*. Equilibrium *G* is equivalent to *C* in Figure 1. It requires power and coercion on the part of employers. Even if longer work hours keeps female productivity closer to the male levels, either misperception or the power of employers can extract the excess productivity, while offering lower wages. Such power can come from custom, which limits what employers need to offer women. An example of such norms is the belief that women workers are often more amenable and less demanding. Only the most determined females would work, since rewards are lower even if she puts in longer hours.

Result 5 Relatively low female earnings promote inequity in household income distribution and power; inequality encourages egoistic preferences and bargaining modes of decision-making.

Power corrupts, but apart from human psychology, support for Result 5 comes from the historical association of falling rewards for women's external work with fall in status for women in the home (Boserup, 1970; Fisher, 2003). Household preferences became dictatorial with the patriarch appropriating most of the surplus in feudal societies, and were frozen in laws such as the Hindu Succession Act 1956, which leaves productive assets with male children while girls are given dowry. Women may have been making do with less not because of altruism but because they had no alternative.[15] The household decision mode would turn toward bargaining, and preferences become egoistic for households with women stuck in equilibria such as FD. In developed countries as external opportunities became available, women chose to produce less of the household good. Family sizes shrank and demographic changes occurred. As their education levels and participation in external labor increased, and so did their share of household income,[16] although many of them are still in equilibria such as *AB* or *FD*. Women are said to be more "other regarding" Sen (1985). But human beings have an intrinsic sense of fairness or equity.[17] In the long run, women's greater contribution to household good production requires altruistic mutual preferences so that women are compensated for their lower earnings. But

inequalities in power corrupt and make household members self-seeking, leading to conflict and to strategies that lower aggregate household consumption.

Result 6 If ICT, first, lowers the probability of separation from a job match, and second, reduces the probability of female separation and brings it closer to the male probability, then first, investment in training of women rises and comes closer to male levels. Second, the critical minimum coordinated investment required to make it worthwhile for all firms to invest and all workers to train is lowered. The more agents adopt technology and training the more it pays others to do so. Third, as investment rises above the minimum threshold, innovation and training have a self-reinforcing aspect, leading to the outcome where all invest. Thus ICT helps escape low-level equilibrium traps.

This follows from the model in the previous section and shows how a low-level trap can persist, and also the possibility of cumulative change to a better outcome given the right conditions.

All the equilibria satisfy *rational expectations* because markets clear and expectations are fulfilled. For example, even at equilibrium F (Figure 2) women get the lower wage they expect; expectations are self-fulfilling. Each of the distortions requires targeted interventions. But if the origin of many of the distortions is the household production function, ICT has the potential to attack the problem at the roots, mitigating natural disadvantages. It can improve matching of women's skills and time with available opportunities, and create new opportunities. Remunerative external work that raises skill and wages becomes consistent with the technology of household good production, preventing decay in human capital, and, through upgradation of skills, reversing it faster if it has occurred.

To conclude, remedial policy matched to the type of distortion, and some evidence in support of the results are presented.

7. Conclusion: evidence and policy implications

In the modified collective household model, the production technology for the household good captures aspects of female biology. Women allocate more time to the production of the household good. This lowers their productivity in the external labor market, and by lowering learning-by-doing in remunerative skills, lowers future earnings as well. Perceptions, of women and of their employers, and imbalance in power, magnify the distortions. ICT has the potential to mitigate this waste of human resources and lead to virtuous cycles of innovation and training.

Our analysis suggests the participation of women in ICT should rise despite distortions. But for it to become substantial, perceptions of limitations, exclusions due to power and self-reinforcing traps have to be removed. In 1999, women were 38% of US Internet users but overtook men in 2000. This happened despite initial doubts about women's ability to participate in the Internet revolution. Huyer (2008) lists 10 countries in which women's share was half or more of all Internet users in 2006. Philippines had the largest share at 58%. Even Thailand (52.6) exceeded the US share of 52%. Thus even in middle-income conservative Asian countries, women's use of the Internet expanded substantially.

Thus, inequalities in participation are not sustainable, given the inherent advantages to women from ICT. But fears that the high tech world could be used to exploit them have some validity. Thus, even with high Internet use, Philippine women's average workload was 21% more than that of men while earnings were only 59% of average male earnings (Hausmann et al. 2006). Full equality continues to be elusive, and the gender gap is persistent. That equality in Internet use is faster than full social and economic equality supports the implications of our model.

Although all types of women stand to gain from ICT, since the rigidities in household production affect them all, differences of education, access, social support and free time limit benefits. These limitations are especially severe in developing areas. For example, in the Arab States where social restrictions on women are heavy, women account for less than 10% of Internet users.[18] Pham Lobb (2008) found women's share in a sample of Vietnamese software firms to be only 34%. Questionnaires revealed the reasons to be biased perceptions of women's skills, the glass ceiling, their compromising for the family and low-skill tasks given to them.

But even for poor rural women access is improving through telecenters and net-based community centers, cyber cafes, kiosks and possibilities from greater mobile penetration, which can enable mobile Internet services. The Internet improves returns to self-employment and lowers transaction costs to entrepreneurship by women. It helps small businesses in many ways – displaying goods, checking prices, making contacts[19] and writing contracts. Telework or distance work, and distance learning to maintain, upgrade and acquire new skills is increasing with the new technologies. Companies are also using teleworking to utilize skilled women who have left full time work, to maintain the skills of their young female employees, and offer flexible wage-hour combinations that offer more choice to employees, allowing them to adapt work to life-cycle needs.[20]

But distortions and perceptions accumulated over centuries will take time to reverse. Policies are required to help the process. Among the most important is improving high-speed broadband access to ICT, and mobile Internet with special facilities for low-income and rural women. This is the pre-requisite for the advantages of flexibility to kick in, and improve Indian female labor force participation. But complementary social change and sensitivity to gender issues in policymaking are required to facilitate these policies. If women had more equal political representation, women groups could participate in ICT policymaking and push their issues.[21] For example, in India broadband availability[22] in 2008 was still limited to 256 K, when 1–2 MB lines were commonplace in the West. Users remained far below policy targets. This happened despite rapid strides in telecommunications and outsourcing. Public sector incumbents, who prevented last mile access to competitors, were part of the blocks. With more gender sensitivity and realization of the social significance of broadband, non-discriminatory access for telecom operators would have been enforced.

The matching model showed the externalities education and training of women create for society. This, and the persistence of biases, calls for a special effort to deliver technical education to women. Research suggests women learn best in non-threatening environments. More women's only institutes and access sites with special content and support for women should be encouraged. Local content is required for real benefits (Roman & Colle, 2003). It is more efficient to subsidize providers rather than users of content for women. Special facilities should be provided to cater to low-income and rural women while maintaining respect for diversity. They could also be given business training. Distance learning initiatives are especially valuable for women, and could help prevent dynamic inefficiency under interrupted labor supply and separations. While teleworking and flexible job options are facilitated service conditions should be regulated to protect women.

Publicizing examples of women's success in Internet-related businesses would help to raise awareness, and overcome perceived limitations. Human intermediaries and social leaders are invaluable for this function, since learning by example is the most effective. The focus should be on a few user demanded services. Since mobile penetration far exceeds that of the Internet in poorer areas, it offers scope for many Internet related services, allowing progress in affordable low-end technologies (Cecchini & Scott, 2003). Self-help groups and NGOs should be encouraged to set up multi-purpose networks and community centers with ICT facilities. Hafkin and Taggart (2001) point out cost of access is very high in countries like Bangladesh – it should

be subsidized for target groups. Easily available good childcare facilities also counter the initial distortion from the household production technology.

More formal tests will become possible as data on experience with ICT collects, even so the evidence does support the theses first, that ICT is uniquely suited to women since it mitigates the source of distortions. Second, distortions get entrenched in social processes. The literature on ICT4D finds positive contributions, but it also brings out many of the social biases, so that access to ICT alone is insufficient. Other policy support is also required. Even so, it may not be the small difference in women's biology that disadvantaged them as much as the absence of compensating opportunities. Technology may, in interaction with social change, remedy this.

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Notes

1. Figures from World Bank http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTGENDER/EXTANATOOLS/EXTSTATINDDATA/EXTGENDERSTATS and a 2007 survey by the Invest India Economic Foundation reported in http://economictimes.indiatimes.com/News/News_By_Industry/Jobs/Reality_byte_Only_13_of_Indian_women_work/rssarticleshow/2843467.cms
2. Hafkin and Taggart (2001) have a table contrasting a gender aware to a normal approach at the different stages of policy-making. Beneria (2003) makes a passionate case for policy to put real people and their needs before markets.
3. Loh-Ludher (2007) reports this as happening in a survey of home-based work in Malaysia. Despite low self-esteem and a culture of sacrifice, contribution to household income does lead to more help from husbands. This is specially so when skill levels increase through well designed programs such as the Salaam Wanita run by the NGO, eHomeworkers.
4. If a household's resources are fully utilized in a Pareto efficient outcome, one member would have to be made worse off to make the other better off. If, however, there are inefficiencies, removing these could make both better off. The analysis suggests ICT enables better utilization of household resources.
5. More complex models would include markets for money, financial assets and for foreign exchange. Because of the adding up condition, in a system with n markets, equilibrium in n-1 markets implies equilibrium must hold in the nth market. This is known as Walras law.
6. The assumption on production functions need not be taken literally. It is meant to capture the higher costs of full time work, lack of flexibility in work location and of travel for women.
7. These production functions capture the stylized fact that women tend to specialize in lower skill, "caring", less time intensive jobs.
8. Endogenous growth models have a similar reconciliation of increasing returns to scale with determinate firm decisions (Romer, 1989).
9. Maintaining unequal distribution and power may be another reason the household ignores dynamic inefficiency. This would not apply to a rational forward-looking household interested in maximizing the present discounted value of its future income. But even for such a household, social norms such as employer's perceptions may make it difficult to prevent dynamic inefficiency (Result 2, Section 6.4).
10. This may refer to individual utilities if the household dissolves or to the inside options available if they stop cooperating.

11. It simplifies and adapts to the heterogeneous worker context, a model developed by Acemoglu (1997).
12. A study by Hewlett et al. (2004) reported that although 41% of workers in science, engineering and technology are female at the lower rungs, 52% leave their jobs over time.
13. Akerlof and Kranton (2000) explore how gender identity (a sense of lower self-worth) can explain the unequal treatment of women in the workplace.
14. Maithreyi Krishnaraj pointed out to me that in the early literature, lower female productivity at external work was thought to lead to corner solutions, with females specializing in homework. Such an extreme solution would not qualitatively change our results but is ruled out in our model by the assumption that both labor inputs are required. It remains a possibility under the decay of skills reflected in equilibria such as ED, when the gap becomes very large.
15. Sen (1984) reports that in a survey carried out in Bengal, women were eating much less than the men, but when asked it was the men who said they were dissatisfied.
16. Browning, Bourguignon, Chiappori and Lechene (1994) test the collective household model with data for Canadian childless couples and find support for the bargaining version. The personal consumption of women increases with their wages.
17. Experimental bargaining games have demonstrated this (Roth, 1995).
18. Vodanovich et al. (2010) show how social, cultural and political norms create barriers to the empowerment of women in the UAE, with even educational schemes limited by male dominance and design. Gender sensitivity is required. Even so interviews with women in the ICT sector reveal they see ICT as a valuable enabler of modernization without westernization.
19. Qureshi (2009) surveys research that demonstrates the use of web tools by Tanzanian women exporters to expand networks, build and maintain trust with foreign buyers.
20. The Tata Group (India) has launched a Second Careers Internship Program for women. They offer packages like live business projects covering 500 h of work spread over 6 months. IBM offers various work-life flexibility options. Employees always have the option of coming back to normal schedules according to their convenience. But these are a few enlightened companies in a majority following traditional ways of working.
21. Qureshi (2003) reports a study that found the most important factors for ICT diffusion were mobile phones and Internet hosts but also civil liberties and political rights.
22. In 2009, the broadband subscriber base was a mere 6.8 million in a country of over a billion. The Indian Government defines broadband as starting from 256 K.

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Appendix

Proof of Lemma 1 Differentiating CS with respect to h_F and h_M gives equilibrium h^*:

$$q'(h_F*) = (1 - r) = q'(h_M*) \quad or \quad h_F* = h_M* = h*.$$

Since male and female workers invest equally in training their productivity is the same.

If $f = 0$, or no firms innovate, the first-order conditions become:

$$\frac{(1+r)}{(1-s_M)} = q'(h_M^{**}) < q'(h_F^{**}) = \frac{(1+r)}{(1-s_F)}.$$

In this case, a double star denotes equilibrium choice of h. The inequality follows from the assumption $s_F > s_M$, and the concavity assumptions. If equilibrium male marginal productivity is less than female, it follows that investment in male training has exceeded that in female. Hence:

$$h* = h_M* = h_F* > h_M^{**} > h_F^{**}.$$

Proof of Lemma 2 The critical or threshold level of $f = f_c$, is the point where gross return (GR) equals cost (C). Above f_c all firms will invest since gross returns exceed cost and below which no investment will be undertaken.

If $f = 0$, gross returns (GR) are:

$$GR_0 = (1 - s_M)q(h_M^{**}) + (1 - s_F)q(h_F^{**}).$$

And costs are:

$$C_0 = (1 + r)h_M^{**} + (1 + r)h_F^{**}.$$

If $f = 1$, gross returns and costs respectively are:

$$GR_1 = 2q(h^*),$$

$$C_1 = (1 + r)(2h^* + \tau) = T(1 + r).$$

Although investment is productive, separation reduces returns at $f = 0$. It follows that $2q(h) > T(1 + r)$ and $GR_0 < C_0$, so $GR_1 - GR_0 > C_1 - C_0$. The GR and the C curves in Figure (3) are obtained by joining GR_0 to GR_1 and C_0 to C_1, their respective values when $f = 0$, and $f = 1$. The C curve is flatter than the GR curve. Therefore the two curves intersect. The value of f at the intersection point is f_c. Above f_c, GR $>$ C, so f rises.