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# Changing Technologies of Household Production: Causes and Effects

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One of the most interesting topics in the area of economics of family and household is how changes in household technology have affected both household production—the production of goods and services by household members for consumption by household members—and market production—the production of goods and services by paid labor, meant for sale. These changes have also apparently led to profound changes in consumption patterns as well as changes in time use, including women's increased participation in market production. Less obviously, but even more profoundly, they have apparently led to significant changes in our most fundamental choices regarding who we live with and how we live.

Most if not all of us alive today and reading this essay can likely not remember a time when electricity did not power our homes, and multiple home appliances run off that power. As of 2012 when I am typing these words (on my home computer, rather than pen them or typewrite them on a manual typewriter), the modern kitchen is a marvel of capital investment, and in addition many homes in the industrialized world harbor modern laundry facilities, let alone garage door openers, vacuum cleaners, and internet access.

Yet many home activities also remain fundamentally the same: we still prepare food and consume it—albeit with more store-bought prepared ingredients; tend to personal hygiene; store our possessions; interact with family members and friends; sleep; and clean our abodes. In many ways our homes function much as they did two hundred years ago, though clearly much greater changes become notable as we go farther back in human development, including the absence of

fixed residences and few if any personal possessions. So an alternative viewpoint might be that very little has changed about fundamental human existence and needs: it is all about quantity and quality rather than fundamental changes in what we consume.

Similarly, while women are now much more likely to work outside the home and have many fewer children in the past, it is also notable that much of what women do in the market often emulates their traditional home-based activities, such as preparing food, cleaning, and tending to children. In addition, while we are much less likely in most middle-class societies to have live-in servants, we procure a wide range of household services from multiple vendors, including gardening services, housecleaning, and childcare. Thus while the labor intensity of any one home activity is often lower, overall we still devote much time to household maintenance, both in our individual homes and economy-wide, and often invest more in terms of time and money per child raised to adulthood.

This chapter considers several interrelated questions. First, the historical question of what actually happened as various technologies were developed and adopted, and what spurred their development in the first place. In particular, was women's increased market work participation enabled in large part through the development of household technologies, or did the technologies develop in response to increased demand in the market sector for female labor? Second, how much has technology "liberated" us from the tyranny of home production, as opposed to being marshaled in order to produce yet more at home? Third, how much has household technology changed not only our time use patterns and our division of work between market and home production, but also the very structure of our households—such fundamental matters as who, when, and whether or not we marry, whether or not we stay married, where we live, and how many children we have? Fourth, has technological change in household production made us

better off? Fifth, given that much of the world has not yet undergone the full household technology revolution, what can we expect to happen in the developing world over the near future, and will responses to technological change mirror those changes seen earlier in the now-industrialized world? And finally, a short speculative section, considering what additional changes may occur in the future in the industrialized world as household technology continues to evolve.

While these questions can be addressed using recent economic research, the answers are not uncontroversial. In this essay I marshal the most recent evidence available, as well as considering older but still relevant sources. However, further research may turn over the statements made herein, as this area of study is still young and contested.

**Is necessity the mother of invention?**

An interesting question about technological innovation in general is how much it is the product of inspired individuals, working essentially from internal motivation, and how much it is stimulated by external forces, for example increased incomes in society and changing opportunity costs of time. The answer is likely twofold in that we could have always used various innovations, such as antibiotics, but general scientific knowledge has to progress to a certain level, as well as individual insight occur, for the product to be invented. But subsequent rapidity of dissemination of innovation appears to depend both on the price of the product and the degree of its desirability, as well as the ability of dissemination channels to produce and distribute items quickly, and the degree to which the innovation depends on additional infrastructure, such as electrification. In the case of household production, it appears that much of the innovation in this area, and the introduction of capital equipment into household

production, had to wait for the second industrial revolution, which is characterized in part by the introduction of widespread electrification at the end of the nineteenth century. This is not surprising, as earlier forms of harnessed energy, such as coal and gas, while utilized for specific household purposes such as home heating and powering of stoves, were not as suited to other types of purposes like refrigeration.

Take a particular case of a particular household appliance, such as the washing machine. Clearly women for generations before its invention could have envisioned that having a machine that washed clothes automatically would be a big time and effort saver. But actually using a washing machine in one's house would depend on the availability of electricity and running water, having enough space to store it, and having the funds to purchase and maintain it. In addition, for many persons, sending laundry out for commercial laundering, or having a servant do the laundry, could be a more cost-efficient way of dealing with clothes. Also those with fewer clothes and sheets to launder would have less incentive to invest in such an appliance as opposed to going, and if cleanliness standards are lower then one also washes less often and has less incentive to buy such a machine. And thus even today, many households do not own a clothes washer due to one or more of these reasons.

Notably, there was no single inventor of the clothes washer, and multiple competing models have always existed. Washing machines predate the invention of electric-powered washing machines by over a hundred years, as patents were issued for them as early as 1691 (Stanley 1995: 301). Washing machines could be turned by crank or powered by running water or steam, for instance. However, the first electric-powered washing machine appears to date from 1904 (Des Moines Daily Capitol 1904), and certainly could not have been much earlier, given that electric power was not available. Central electrical power stations were first available in the

late nineteenth century—1881 in Surrey, the United Kingdom; 1882 in New York (McNeil 1990: 360-68).

While much early use of electricity was in production, in factories and offices, home electrification spread fairly rapidly in the US. In 1920, one-third of homes had electricity; by 1930, over two-thirds were electrified (although only ten percent of farm homes); by 1960, practically all homes were electrified (Vanek 1978: 363). Similarly, by 1940, seventy percent of homes had running indoor water (seventeen percent of farm homes, ninety-three percent of urban homes); by 1970, ninety percent of rural homes had running water (Vanek 1978: 363). Thus the infrastructure necessary for households to be able to utilize household appliances such as dishwashers, refrigerators, freezers, clothes dryers, and vacuums was widely available already pre-WWII, and ubiquitous in the postwar era. Similar to the story of the clothes washer, these other appliances also developed from early hand-powered prototypes into versions driven by electricity and hooked up to household water sources in the case of those that needed water to run. Bathroom appliances dependent on running water, such as the flush toilet and showerhead also became standard household equipment during the first half of the twentieth century.

Once electrification became standard, later waves of household appliances, particularly smaller non-built-in ones, disseminated much more quickly. For example, the microwave oven rose from adoption by thirteen percent of married-couple households in 1978 to eighty-one percent a decade later in 1987 (Oropesa 1993), and about twenty-five percent of all households by 1987. Thus, for later appliances, it may be that their invention was in response to the desire of households for yet more reduction of time and effort in household production. However, even in the case of the microwave, it was first necessary that the physics of microwaves be understood and harnessed, and the Radarange was already commercially available by 1947. But it took

another two decades for a home Radarange to become available, and even then it was at prices that few could afford ($495 in 1967 dollars). Again, until the prices of microwaves dropped much further, households might well have appreciated having such a product, but were unable to afford it.

Thus both the timing of the invention and adoption of these technologies, and their dependence on the networks of electricity and running water, appear consistent with a story that their appearance made it possible for people to spend less time in household production, in particular women. Thus it may be that one of the explanations for the increased participation of women in paid work is that these technologies were invented. Whether or not this was the case we will examine in the next section.

**How much liberation has occurred?**

Overall, US investment in household durable goods has more than tripled over the course of the twentieth century as a percentage of GDP, and the stock of such appliances doubled (Greenwood, Seshadri, and Yorukoglu 2005: 111). So with all of this investment in household capital, has there been liberation of people from time spent in household production? Note this implies that most people find household tasks onerous and that they prefer other uses of their time to household production. It also implies that quality improvements in household production are minimal, that clear standards for household cleanliness and appropriate meals can be stated and followed, and that the nature of household production has not altered over time. All of these assumptions may well not be true.

The simplest way to answer this question would be to look at time use patterns to see what has happened as appliances have been increasingly used and electricity and running water

available. This would include looking in particular to see whether people shift time out of household production and into other time use, including market work and leisure. But this evidence is not systematically available, particularly for older periods. Thus researchers have considered a range of phenomena, including more limited time use studies of how long households with various appliances spend on household chores, and whether women have increased their market work time as such appliances have become increasingly available. Indeed, one of the most interesting recent debates in the economics and sociological literatures has been over whether changes in household technology are responsible—and if so, to what degree—for the rise in female labor force participation that occurred in developed countries during the twentieth century.

Figure 1 shows the patterns over the past 210 years in women's and men's labor force participation, as well as women's percentage of the labor force. While women's participation rises over the full period, the most notable change occurs in the post-WWII period. This rise coexists with a drop in men's participation, with the net effect being that women rise as a percentage of the labor force up to forty-seven percent by 2010.

< Figure 1 about here >

In addition, it is particularly notable that the growth in female labor supply that began during the second half of the twentieth century and up to the present, came from married women with children. Single women were already mostly working. For instance, in 1960 single (never-married) women had a fifty-nine percent labor force participation rate, which rose to sixty-five percent by 2010. But the married women's labor force participation rate rose from thirty-two percent in 1960 to sixty-eight percent by 2010, surpassing the single women's rate. In particular, married women with school-age children (children ages six through seventeen) rose from thirty-

nine percent to seventy-seven percent participation rate over this period, and even those married women with preschool-age children saw their rate rise from nineteen percent to sixty-four percent over this period. (U.S. Bureau of the Census 2004: 376-77; U.S. Bureau of Labor Statistics (2011): 12; 16).

Many economists and other social scientists have attempted to figure out which are the most important factors causing this rise. As usual, economic theory can provide a guide as to what might be relevant factors—particularly through use of the concepts of substitution (in both production and consumption) and income effects, but cannot say definitively whether particular factors have actually caused the increase or not. Factors can be divided into demand-side and supply-side factors.

Demand-side factors influence individual labor-supply decisions by increasing the wage that women can potentially earn. The three demand-side factors that are generally cited as of primary importance in explaining the rise in female labor force participation are the general rise in the demand for labor, the rise in labor demand in particular sectors, and the rise in skill demand. Demand for labor has been rising over most of this century, subject to business-cycle fluctuations around the long-term upward trend. Since labor demand is derived from the demand for goods and services, as the volume of traded goods— both domestic and international— has risen, more labor has been needed to produce these goods and services. Technological innovations have led to increased demand for labor as production techniques have become more efficient, leading to increased output per worker. While demand for particular types of labor has fallen, in particular unskilled farm labor (where other inputs, in particular capital, have been substituted for labor) and both skilled and unskilled labor for use in manufacturing (where some capital substitution has occurred and growth in demand for manufactured goods has been lower

than growth in demand for services), demand for other types of labor has been growing faster than average, in particular for clerical and service occupations which have been areas in which women have traditionally been more represented. Finally, shifts in demand for goods and services and the complementarity between capital and skilled labor—along with the substitutability of capital for unskilled labor—have led to increased demand for skilled workers relative to unskilled. As women have become more educated, the consequent rise in their potential wage has made it more profitable for them to enter into market work (Black and Juhn 2000).

Indeed, wages for women rise substantially in both absolute and relative terms over this period, with median annual incomes for women rising from sixty-one cents per dollar earned by men in 1960 to seventy-seven cents in 2011 for year-round full-time workers (U.S. Bureau of the Census Current Population Reports No. 132: Table 43; No. 243: Table A-4).

As women's wages have risen, the only way to realize gains from the rising wage is to work, so we would predict a rise in women's labor force participation. While women who are currently working may reduce their hours due to the increase in wages, they will remain employed, so the net change in female labor force participation is positive. Many analysts have argued that real wage growth can explain most of the increase in female labor force participation between 1950 and 1980 (e.g. Smith and Ward 1985).

In addition to demand-side factors operating through the wage to cause movements along the female labor supply curve, there are three groups of supply-side economic factors that must be considered that could shift the supply curve: changing technology of nonmarket production; changes in family composition; lower male earnings, translating into less nonearned income

available for married women. We will consider the first of these three causes in most depth herein, as it relates to the main topic of this chapter.

Changes in the technology of nonmarket production have two aspects: the greater availability of market-produced substitutes for nonmarket goods and increased efficiency of nonmarket production, particularly housework. As more market substitutes are available for nonmarket goods at lower prices, this will have the effect of increasing labor supply because the efficiency of market production has increased - i.e., the real purchasing power of money wages has increased.

But consider the effect of changes in production efficiency on the household production frontier for a married couple when the wife currently does only nonmarket work and the husband does only market work. Make the realistic assumption that both market and nonmarket production are normal goods, so that when potential income rises, more of both will be consumed. Then economic theory does not tell us whether increased efficiency in either form of production will lead to more or less time spent in the relatively less efficient form of production. Due to the opposite directions of the substitution and income effects, we cannot predict the exact direction in change for the good that becomes relatively more expensive. If market efficiency increases - e.g., if the wage rises for both family members, the substitution and income effects of this wage change cause an unambiguous increase in consumption of market goods, but nonmarket goods can either increase or decrease depending on whether or not the income effect dominates the substitution effect. We cannot tell if the wife will now participate in market work. Similarly, if nonmarket efficiency increases, there will be an unambiguous increase in consumption of nonmarket goods, but market goods can either decrease or increase, and we cannot tell whether the wife will participate in market work.

Thus, productivity gains in household production may or may not translate into less time spent in household production. After all, as the cost decreases of producing housework, and of producing higher-quality housework, households might well demand more of it. Indeed, Ramey (2009) concludes that while there was a fall in women's housework hours from 1900 to 1965 of six hours per week, that this fall was balanced by a rise in housework by other persons.

In evaluating what has happened, it appears that many supposedly timesaving innovations were widely adopted in the first half to two-thirds of the twentieth century with no apparent significant reduction of nonmarket time (Cowan 1983, Robinson and Milkie 1997). For instance, Manning (1968) compares time spent in preparing meals by families with and without various cooking appliances (mixers, electric skillets, pressure cookers, freezers, and dishwashers) and finds that the families with the appliances basically spend the same or more time in meal preparation. While this could be due either to a direct effect, or to a sample selection effect (families that spend more time in preparing meals may be also more likely to purchase these appliances, perhaps because they enjoy spending time cooking), in either case there is no direct evidence of liberation. More broadly, Bose and Berano (1983) consider four types of household technologies: utilities, appliances, convenience and prepackaged foods, and private sector market services (p. 85) and conclude that none of them truly saved, or freed up, household labor (though they do suggest that utilities saved physical exertion).

It is of course quite possible that the families who own these appliances are creating greater value of household production, since they both invest more capital and the same amount (or more) of time in meal preparation, clothing maintenance, and other household chores. For example, Mokyr (2000) argues that the rise in understanding of the causes and transmission of infectious diseases in the early part of the twentieth century increased housewives' attention to

home hygiene. Vanek (1974), in examining a set of about twenty small-scale time-use studies done under U.S. Bureau of Home Economics guidelines from the 1920s through 1960, finds a remarkably stable number of hours spent in housework for women who did not work also outside the home, staying in the range of 48 to 56 hours per week. This is barely any change from 1900, where it is estimated that the average household spent fifty-eight hours a week on housework (Lebergott 1993: Table 8.1). The composition of housework has changed over time however, with less time spent on food preparation and cleanup, and more on shopping and family managerial tasks (Vanek 1974).

A different take on the lack of change in housework hours is that, at least for women who do not engage in market work, chores expand to fill available time. This keeps women inefficiently occupied in the home, reducing their market work.

Analyses of reading material meant for a female readership tend to support the views that much of housework is ``make-work'' and that social standards for housework are unnecessarily strict. Margolis (1984) argues that there is a tendency in women's magazines and newspaper sections to emphasize activities in the home that have visible results, such as home decoration. She believes that the purpose of this emphasis is to validate the importance of housework and that it thereby supports this inefficient housework system. However, she also concludes that there is a somewhat opposing tendency for the prescriptive literature on mothering and housekeeping practices to support the increased demand for female labor. Margolis (1976) also analyzed a sample of two hundred hints taken from seventy "Hints from Heloise" columns published in January-March 1975. She concluded that of these hints, thirty-eight percent were needlessly time-consuming, forty percent were neutral with regard to time use but were often superfluous activities, and only eight percent were actually time-saving ways of performing

useful chores. Certainly modern upscale housekeeping magazines, such as *Martha Stewart Living*, rarely if ever emphasize time-saving aspects of their household suggestions, focusing often instead on the beauty and handmade aspects of the suggested crafts and recipes.

Similarly, Fox (1990) analyzed advertisements for household appliances in the prominent women's magazine *Ladies Home Journal*, measuring the percentage of ads that extolled the labor-saving character of household appliances. She surveyed ads at ten-year intervals, starting in 1909-10 and concluding in 1979-80. In 1909-10, twenty-one percent of the ads stressed the labor-saving nature of their product; the percentage dropped to thirteen percent in 1919-20 and 1929-30; rose to nineteen percent in 1939-40 and to twenty percent in 1949-50; and fell to between five and six percent in both 1969-70 and 1979-80. She concludes: "More *Journal* ads featured directives about housework than descriptions of the product; they emphasized work performance far more frequently than liberation from housework, and they also promoted service to family…advertiser's [sic] efforts to create a market for household appliances and other means of domestic labor involved promotion of an ideology about housework that reinforced women's dedication to it" (p. 25).

However, the story appears to change over the second half of the twentieth century. Over this period, more systematic time use data become available. For the US, American Time Use Survey data, available annually since 2003, can be linked up with older data from decadal studies (1965, 1975, 1985) to characterize the changes in time use over the past forty-six years. Over this period, there appears to be a drop both in women's time spent in household production, and in total time spent in household production. As shown in Figure 2, the drop in women's average weekly hours from 1965 to 2011, going from twenty-seven hours to fifteen, is not offset by the

rise in men's hours from five to ten. So women still spend more time in housework than do men, but the total amount of housework done per household is dropping.

< Figure 2 about here >

What happens with the freed-up time? Much of the freed-up time for women appears to be going into paid work, though some of it is spent in increased childcare (Connelly and Kimmel 2010). In addition, more time appears to be available for leisure, both over the total lifecycle and even during prime working years: between 1965 and 1985, total hours spent in productive activity (market and nonmarket) declined by seven hours for employed women and by four hours for employed men, implying that pure leisure has risen for both groups (Robinson and Godbey 1997: 108).

But there are other possible causes of these changes besides liberating household technology. In particular, it has been disputed as to whether or not the increased and lower-cost availability of household utilities and durables goods is responsible for much if any of the rise in women's labor supply, with researchers coming down on both sides of the argument.

An influential paper, "Engines of Liberation," by Jeremy Greenwood and colleagues (Greenwood, Seshadri and Yorukoglu 2005), has put forth the argument that household technology adoption is responsible for about fifty-five percent of the rise in female labor force participation over the twentieth century, and that rising relative wages for women are only responsible for about twenty percent of the rise. While the authors acknowledge interaction effects, they still argue that without the availability of liberating household technology, rising wages alone would not have been sufficient to draw women out of the household.

Jones, Manueli, and McGrattan (2003) disagree. They analyze the 1950-1990 period and conclude that changes in household production have almost no impact and that the changes in the

relative wages explain both the rise in married women's market work and the simultaneous lack of change in work hours for men and single women. Particularly for the earlier part of this period, Greenwood et al's work, which also emphasizes the slowness of market hours adjustment to the new state of household technology, seems consistent with this story; the disagreement is more about the later part of the century.

In addition, there are numerous other changes that occur during this period that could also affect female labor supply directly. Medical technology that have made it easier for women to control timing of childbirth, as well as reducing the difficulty of childbirth and making it easier to raise young children, are key additional technological advances that occur during the twentieth century. Albanesi and Olivetti (2007) argue that these medical technologies, including the development and declining cost of infant formula, were key in freeing up women's time for market work. Goldin and Katz (2002) discuss a later transformative medical technology, namely the invention of the birth control pill—approved for prescription by the FDA in 1960, as a crucial factor particularly for enabling college-educated women to continue their education and careers. And, in part as a consequence of these technological changes, the large demographic changes that have occurred, all of which tend to increase female labor supply: later or no marriage, increased divorce rates, fewer children later in life, and smaller household sizes.

However, there is additional recent evidence that the latter half to one-third of the twentieth century did see time freed up from the household sector by laborsaving technology. Cavalcanti and Tavares (2008) find a relationship between the decrease in home appliance prices in OECD countries from 1975 to 1999 and the increase in female labor force participation. For the US, Coen-Pirani, León, and Lugauer (2010) argue that the increase in married women’s labor force participation during the 1960s is related to increased appliance ownership (specifically

freezers, washers, and dryers). The earlier half of the twentieth century still displays little evidence of a direct effect: Cardia (2010) tests the Greenwood et al. hypothesis for the period of 1940 to 1950, using US Census data that includes information on presence of indoor plumbing and refrigerators. She finds some effect of indoor plumbing, but not of refrigeration, on differences in female labor force participation across states in 1940, and some evidence of increased female participation in the clerical sector.

So has there been liberation? The current assessment appears to be yes. If a person chooses not to spend more than a minimal amount of time in household production, it is now possible, with the aid of household appliances, to do so. This minimal amount may be in the range of one to two hours a day in total person-hours for a two- to three-person household observing reasonable cleanliness standards of a middle-class level.

However, many households still choose to spend more time in household production, perhaps because they either enjoy aspects of it, or because they hold themselves to a higher standard. In addition, to the extent that they must work in order to purchase market substitutes for nonmarket production, such as prepared food and manufactured clothing, on top of paying a house mortgage, a car note, and schooling expenses, liberation may not be the first term that comes to mind to many two-worker households struggling to pay their bills.

**How have households changed?**

The demographic changes that have occurred during the twentieth century in industrialized countries are nothing short of revolutionary. In particular, the tremendous drop in women's lifetime fertility, combined with remarkable lifespan lengthening, have meant for the first time in

human existence that adult women spend a large proportion of their life not directly engaged in pregnancy, childbirth, and child raising.

Figure 3 shows the precipitous long-run decline over the past 210 years in the U.S. birth rate, dropping from fifty-seven per thousand persons in 1800 to thirteen per thousand persons in 2011. The post-World War II baby boom (and a subsequent early 1990s echoing boomlet) interrupts the long-run downward trend and help motivate why mothers in the 1950s and 1960s might still have had high levels of household production related to those larger families.

< Figure 3 about here >

Similarly the long-run rise in age at first marriage is disrupted during this period, even as recent numbers have seen median age at first marriage reach recorded highs. In 1900 the median age at first marriage was 26 for men and 22 for women; in 2011 it was 29 for men and 27 for women (U.S. Bureau of the Census, 2011a).

One net effect of increased lifespans, the higher age at first marriage, the higher divorce rate, and the lower birth rate has been to generate a large number of smaller households. In 1960 the average household size was 3.3 persons; as of 2011 it is 2.6 persons. In 1960, thirteen percent of households consisted of single persons; as of 2011 it is twenty-seven percent of households (U.S. Bureau of the Census, 2011b).

While there are likely economies of scale in household production, it is also the case that households with larger numbers of dependents imply more work for the middle-aged adults housed therein. Also childless households have very different types and degrees of household activities. So these household composition changes imply changes in household production, including potentially modified social standards of what constitutes reasonable housekeeping. Thus some reduction of housework can have come from the combined force of smaller

households, in particular fewer children and more singles. On the other hand, in older times, economies of scale were obtained in other ways, particularly for unmarried persons, such as more group living (rooming houses, taking in boarders) and smaller house sizes.

While it is the case that changes in household composition can cause changes in market-nonmarket work patterns, a perhaps more interesting question is how changes in household technology might have led in part to those changes in household composition.

A chain of causality might be as follows: more efficient household technology, combined with rising market wages, induces women to enter the labor force. Working women are more likely to delay marriage and childbearing and to have fewer children. They may also be more likely to divorce rather than stay in an unsatisfying marriage, and not to remarry if they see less material gain from marriage, thus leading to higher rates of single-person households at all points in the lifecycle.

Greenwood and Guner (2008) make a stronger argument regarding how changes in household production technology have affected the very nature of marriage. While traditional marriage implied more specialization of women into household production and men into market production, modern times reduce the economic incentive to marry so as to gain materially from specialization and exchange within marriage. Thus there might be both less marriage, and also more marriage occurring for love and emotional or companionable compatibility rather than for economic grounds. Greenwood et al. (2012) go further in developing a unified model to explain changes in marriage, divorce, educational attainment (particularly of women), and married women's labor force participation. They also emphasize the increased amount of assortative mating by education level, where men and women are increasingly likely to marry people with relatively similar earning potential.

Stevenson and Wolfers (2007) point out another mechanism by which changes in household production technology and availability of market substitutes have affected the gains from marriage. Some of these changes have reduced the need for people to develop skills that are useful in household production. For example, the availability of commercial canned goods means that households need not do their own canning. To the extent that male and female children used to be trained in different household production skills—or girls trained in household production skills while boys were trained in labor market-relevant skills—they would arrive at marriageable age having very different sets of skills—and in the case of girls, often skills that were only useful within the context of household production. Now children are trained more similarly, including being more likely to spend their adolescence in secondary education and school-related extracurricular activities. One wonders if the feminist revolution was effected in large part by mothers, whether consciously or not, simply not training their daughters in the skills necessary to reenact their own household-centered lives. And thus both the gains from marriage and the decision of whom to marry has been affected—for one thing, both men and women may look for high-market earners rather than the relatively rare potential spouse who has high household production ability. This ties in with the increase in assortative mating by earnings potential that Greenwood et al. (2012) note: everyone would like to marry a high earner, but only other high earners are able to close the deal

Fernández, Fogli, and Olivetti (2002) analyze another mechanism by which household technology could have had an effect, again related to the effect of increasing married women's labor supply, but this time through affecting men's marriage preferences. More men in recent generations experienced a family model in which their mother was educated and worked for pay. Thus, if men are inclined to marry women that are in many ways like their mother, they will be

less likely to look for marriage partners who want to specialize in household production. This may be not only because men want to marry women like their mothers, but also because both men and women are accustomed from their childhood experiences to be in households where both parents work. Such households may have less household production and less time spent with parents in the home, but also may have more store-bought goods and services, as well as higher money incomes, and these latter factors may be increasingly viewed as desirable as people become accustomed to them.

Thus once the economy starts down a new track wherein more people both work outside the home and purchase market substitutes for formerly home-produced goods and services, preferences evolve to make this path even more likely over time. Again, other factors, such as changes in medical technology as discussed above and many other factors that tend to lead to increased female labor supply, could also have contributed to these fundamental demographic changes. But the mechanism of changing household technology is intriguing and these stories plausible of how it could have contributed to demographic changes.

**Are we better off for it?**

The issue of unforeseen changes in household composition coming as a consequence of household technology changes makes one less sure that technological changes are a clear gain. Even if household structures had remained unchanged it is unclear that increased potential household (and/or market) production makes all household members unambiguously better off. To the extent that household structures are also affected, it may be even more likely that the unforeseen consequences of changing household technology could be on average negative. Let us consider how this could be the case.

In the case where household structures are static, whether household members spend more or less time in household production, it is still the case that the technology has made the household better off in total because of their increased production possibilities (including the possibility of having more time spent in leisure). Nonetheless, even if the household is made better off in total, it can also be the case that the allocation of improvement between household members may or may not end up improving gender equity. For instance, in situations where women can increase production through their labor, but do not have control over the increased product's distribution, it is not clear if their well-being is improved. In general increased market work by women is likely to be associated with increased power as it should improve bargaining positions within marriage due to better fallback positions.

However, better bargaining/power positions does not automatically mean that one is better off. It may be for instance that with more power, career advancement, and money also comes more stress. (talk about stress etc. by looking at what I wrote in Chs. 3 and 5 of my book).

Indeed, happiness research, a growing field in the social sciences, has led to some interesting findings. In particular, rising living standards do not automatically translate into improved happiness. For example, Stevenson and Wolfers (2009) look at changes in men's and women's self-reported happiness from 1972 to 2006 and find that women are now less happy in both absolute terms and relative to men. They argue that the myriad of demographic and work changes that have occurred over this period have thus overall disadvantaged women relative to men.

What about the children? Some indicators of children's well-being show declining well-being, while others show improvement. In the US, children are now more likely to be in poverty than are older persons (sixty-five and over), even as overall poverty rates have fallen. As

incomes have risen in the US and many other countries, there have been increased rates of childhood obesity (and adult obesity), with studies showing between a tripling and quadrupling of these rates since the 1960s (National Center for Health Statistics 2012). On the other hand, infant and child mortality rates have fallen drastically, contributing substantially to increased lifespans. These increases in total lifespan, including higher value per year of life (often measured by disability-adjusted life years) are significant. But many aspects of children's well-being are harder to measure, such as whether they are better or worse off in divorced than in intact families. Certainly children in single-parent families tend to have lower levels of household resources per person. Thus, if technology changes have contributed to more single-parent families, this may be a net negative for children. But the causal links between female labor force participation, demographic changes, and changes in well-being are not well-established, and they need not be either stable or irreversible.

Thus, because household technology changes have either been accompanied by, or have caused, household composition changes, it is difficult to evaluate how much better off it has made people. One approach may be to ask people how much they are willing to give up to achieve various other goals, for instance would they be willing to give up a dishwasher in exchange for a dependable spouse that would wash dishes by hand.

**What is happening now in developing countries?**

It is clear from looking at worldwide adoption rates of household technology that invention is not a sufficient precondition for adoption. Many countries lag well behind the US and other industrialized countries in percent of households owning various appliances. Clearly income level is a more important factor, as well as infrastructure development.

It has become relatively easy to access country-level data through household surveys and other (often industry) sources regarding the extent of connectivity and provision of water and electricity, and the adoption of technologies that utilize this infrastructure, such as phones and household appliances.

Running water for the urban population in particular is mostly a given at this point in time, with seventy-eight percent of the worldwide rural population and ninety-six percent of the urban population using improved water sources (modification from naturally-occurring sources) as 0f 2008 (World Bank 2011), but there are notable variations still in water provision for the rural population across regions and still low rates of improvement for the rural population in low income countries. Meanwhile, sixty-five percent of the worldwide rural population and ninety-four percent of the urban population had electricity available as of 2009 (International Energy Agency 2010).

Information on household use of electrified appliances for a number of lower-income countries are available through the Demographic and Health Surveys program. Information is available for urban and rural areas as well as an overall percentage of electrified households, and for the percent of households (again by urban and rural as well as overall) that own a radio, a television, a phone (here meaning with a landline rather than mobile), and a refrigerator. In general, rates of appliance ownership are lower than electrification rates (on the view that electrification is a necessary precondition), but not always—it is possible to have a battery-powered appliance (particularly a radio or television), or to have access to television or radio through another household or location. Interestingly, the rates of television access are high, higher in many cases than for radio access, perhaps because households now find televisions to be more of a necessity than radios. Landlines are not particularly common, and may lag further

now that mobile phones provide a substitute product. Refrigerators are less common than televisions or radios in general, but more common than landline phones.

Data from the Socio-Economic Database for Latin America and the Caribbean can be used to track a broader group of household appliances including refrigerators, washers, and air conditioners. These data show relatively high rates of appliance availability, though washing machines and air conditioners are much less frequently found than refrigerators. The more middle-class and urbanized the country, the more household appliance acquisition looks like that found in US middle-class households. And indeed, female labor force participation has been rising in such countries as well—and family sizes dropping. Thus a similar demographic transition appears to be occurring in currently industrializing countries—or parts of countries—where household technology has now become common.

But there is still a specific issue in many low-income countries, particularly in rural areas, of women having to spend long hours every day collecting water and/or fuel. Reports of time use studies from these countries often hearken back to discussions of household production in the US from the nineteenth century. For example, Schreiner (1999: 65) mentions "up to six hours per day" spent in fuel and water collection by women in her study in Bamshela, South Africa. Thus it appears that one way to free up women's time both for more productive uses and for leisure would be to reduce the time spent on those activities. But yet again it turns out not to be straightforward how providing better access to fuel and water, or more efficient appliances that utilize fuel and water (in particular cooking appliances) affect time use.

Regarding reducing the time spent in procuring usable water, innovations abound, but generally relate to reducing the distance to the water source (e.g., digging a local well or bringing water closer by pipe or other means), improving its potability, increasing its quantity, and

reducing the amount of physical effort necessary to get it (e.g., pumping technology). But the number of studies that are able to find a measurable outcome related to improved access to water are small (where the two main focuses have been whether time is freed up for more market participation by women, and whether there is better participation of children in schooling).

One issue is whether reducing distance to water source actually reduces time allocated to water collection. Again, as the cost of collection decreases, it is possible that households decide to allocate more rather than less time to water collection and usage, at least in an intermediate range where water is not available at the turn of a faucet in one's house, but is made closer at hand than previously. A study by Ilahi and Grimard (2000), using data from Pakistan, finds that greater distance to a water source does raise the time spent in water collection for women and lowers their participation in income-generating activities. However, in households with "private water technology" (as opposed to public infrastructure outside the home), women spend the freed-up time on leisure rather than on market work. Menon (2009), using 1995-96 household data from Nepal, focuses on the predictability of water rather than distance to source, and finds that household members, including women, are less likely to work in agriculture if rainfall in their area is less predictable, implying that improving water source predictability would increase agricultural activities.

Several other studies find little effect on off-farm work for women, including Koolwal and van de Walle (2010), using data from countries in several regions (sub-Saharan Africa, South Asia, and Middle East-North Africa). This was also the case in earlier studies by Lokshin and Yemtsov (2005) for rural Georgia between 1998 and 2001 (no effect on women's wage employment) and Costa et al. (2009) for rural Ghana.

However, these studies do find other measurable effects. Koolwal and van de Walle (2010) do find that both boys' and girls' enrollments in school rise as the time spent collecting water falls. They also find some improvements in children's health in data from Yemen and Malawi. Lokshin and Yemtsov (2005) find a significant reduction in the incidence of water-borne diseases due to the improvements in water supply. And Costa et al. (2009) do find a reduced time burden on women, just no increase in the time spent in paid work.

With regard to fuel source substitution, while there are a number of potential substitutes for traditional fuel sources used for cooking and lighting (mainly wood), including solar power, rechargeable or long-lasting batteries, and propane, electricity can serve as a substitute as well as being usable in many other ways. Thus, we might expect electricity to have perhaps a more significant effect on women's market labor than does water, because not only does it free up time spent getting fuel, but also may be complementary with other market-related activities.

Indeed, Costa et al. (2009) find that in rural Ghana, unlike for improved water supply, improved electricity availability increases the time spent in remunerated activities. Similarly, Dinkelman (2010) finds that in South Africa, women's employment rates increased significantly (by about 9.5 percentage points) in electrified areas; men's employment was not significantly affected. Grogan and Sadanand (2009) find a similar effect for rural Guatemala, with electrification associated with women spending more time in market work and having increased earnings.

In contrast to these rather sizable effects of improved electricity service, simply improving fuel efficiency by creating more efficient cooking stoves has not been very successful to date. Otsyina and Rosenberg (1999) mention how the rate of adoption of improved stoves (less wood needed, less smoke produced) in the area they studied in rural Tanzania was quite low.

They stress the problems in disseminating the technical knowledge necessary to construct and utilize the stoves, pointing out that transmission of this knowledge is related to gender roles as the women (who would be the primary users of the stoves) were not used to attending technical workshops, and were not out and around in the world as much as the men in order to learn new things. Indeed, there has been a round of more successful adoption of improved cook stoves in Kenya due to more attention paid to dissemination and training (International Centre for Research on Women 2010: 14).

However, the issue of what is done with freed-up labor time, if indeed time is freed up at all, still looms in the back of planners' minds. For countries with apparent excess labor, the advantage of laborsaving devices may not be obvious, and neoclassical economists' views regarding increased productivity leading to higher demand for labor not sufficiently enticing. It is certainly the case that one reason we do not see larger paid work effects from improved water supply may be that there are no paid work opportunities for the women to step into, particularly in the rural areas. Hessler's profile of former Peace Corps member Rajeev Goyal, who successfully developed a pipe-and-pump water delivery system for Namje, a remote Nepalese village, mentions Goyal's concern with "what Namje women would do now that they no longer spent six hours a day hauling water" (Hessler 2010: 106). Indeed, they started a women's co-op and made hats for export (which he sold), but after a while this plan fell through. Without sufficient human and physical capital available that is complementary to paid work, it is not clear that the time can be rechanneled into remunerated work. Thus the secondary development issue is how to develop such outlets once the necessary infrastructure of water and electricity delivery, along with more efficient household technology, is laid down.

**What will happen next?**

The most unsatisfying part of an economics essay is always the part where the author tries to predict what will happen next. Economists are notoriously bad at prediction (and only slightly better at explanation after the fact). Thus this section should be viewed as pure speculation.

For those countries discussed in the preceding section, as urbanization continues to increase and incomes rise, it is likely that they will complete the technological transition to levels similar to those found in the industrialized world, albeit more like the European levels of appliance usage (smaller kitchens, including smaller stoves and refrigerators; smaller washers and less use of clothes dryers) than the U.S. levels of appliance usage, given the likely rising costs of energy and greater space constraints in urban areas.

For those countries already experiencing practically one hundred percent supply of home electricity, running water, and refrigeration, it appears that in many ways the technological revolution of mechanizing household production so as to reduce labor hours and effort in home production has run its course. Anyone who has perused the Williams-Sonoma catalog knows that the types of mechanized appliances now offered to customers are either increasingly specialized tools (panini presses; espresso makers) or minor variants on existing concepts (countertop convection ovens; single-serving coffee machines). Other appliances actually signal a rejection of time-saving (and often less costly) market substitutes for more labor-intensive home production methods (home baby food makers, juicers).

This may be in part because people were not so interested in being liberated from home production as they were in being liberated from the backbreaking, repetitive aspects of household production. Many fewer modern households are choosing to eschew hot running water and electricity in favor of pumping well water, burning candles to read by, and gathering firewood.

The modern middle-class household gets to choose how to manage its household production, rather than having to do it as a matter of life or death. And to the extent that household production can serve as an outlet for creative expression, choosing to make one's own clothing and bake one's own bread moves into the realm of leisure activity and out of the realm of necessity. In particular, for retired persons as well as persons who choose to reduce their market hours, household production can become the wanted rather than the dreaded.

At the same time, many traditional household activities are passing out of the realm of active knowledge transmission from parent to child and into the realm of book learning. It is a rare parent nowadays who instructs their child in sewing and home canning. It is unlikely that these skills will be widely revived.

But meanwhile, other household skills, particularly the ability to manage household finances, including making large investment decisions (saving for retirement, for children's education; purchasing a second home or a time-share) have become more salient. Households who master personal finance skills will likely outperform households who do not in terms of maximizing lifetime consumption paths.

Any additional revolution in home technology awaits the invention of more fully roboticized home production. While isolated technologies, such as the Roomba robot vacuum cleaners, have become more common, full-scale robotization of additional routine home activities appears unlikely without the development of multi-purpose robots that can essentially manipulate objects more similarly to humans, as well as self-perambulating about the house. It is unlikely that such technologies will occur any time soon, as current labor prices will still make servants and maid services a more cost-effective means of factor substitution for the foreseeable future.

And thus the fundamental dilemma, that everyone would like to have a "wife" to do things around the house, remains unsolved. Until the inventions of robotic housekeepers and/or self-cleaning houses and self-cooking dinners come to fruition, the issues of how to do housework and who will do it remain part of the human condition.

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