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Parting with "Blue Monday" – Preferences in Home Production and Consumer Responses to Innovations

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Abstract: How can economic theory explain the reasons why consumers adopt innovations? Using the example of innovations in washing machines two approaches are compared. The first focuses in the manner of household production theory on changes in constraints without specifying preferences, leading to the well-known time substitution hypothesis. The second approach develops specific hypotheses about consumer preferences and focuses on how technical change accounts for them. The two approaches are empirically evaluated with a data set representing the motives suggested in washer advertisements for purchasing new vintages of machines over the period 1888 to 1989 in the U.S.

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Keywords: home production, preferences, consumer motivation, product innovation, innovation diffusion, time substitution hypothesis, direct utility

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1. Introduction

Consumer behavior is an important driver of innovative change in the economy. Countless numbers of newly adopted products and services show this. A case in point is the massive technological upgrading of homes over the past century with household appliances (Cowan 1983, Bowden and Offer 1994, Strasser 2000, Shove 2003). For instance, around 1920 only about 8% of U.S. households possessed a washing machine and the rest still relied mainly on the conventional scrub board (Lebergott 1993, p.113). Today roughly 83% of households have their own washing machine (see EIA 2006; the rest using landlord installed or commercial washing machines). How can such innovative consumer behavior that contributes to the rise of entire new manufacturing sectors be explained?

From the point of view of economic theory, the answer depends on the consumers' preferences and their perceptions of the constraints and changing technological opportunities they face. Yet, unlike inquiries in marketing (see, e.g., Bargh 2002) and psychological consumer research (see, e.g., Markman and Brendl 2000), economic inquiries rarely substantiate their assumptions about consumer preferences. Instead, they give priority to an analysis of changes in the constraints (relative prices, income), following the logic of income and substitution effects. A prominent example of such an approach is household production theory. Working with well-behaved, but unspecified, utility functions, its explanatory variable are the changing opportunity costs of time use (Becker 1965, Gronau 1986, Pollak 2003, and Steedman 2001 for a wider discussion). All that needs to be known in this approach about the consumers' preferences is that they satisfy the formal conditions of transitivity, continuity, completeness, and non-satiation.

However, the success of innovative consumption goods – as, for example, new vintages of washing machines – hinges not only on their relative price and their capacity to enhance the homemaker's time productivity. An innovative product has to appeal to the preferences of the consumers in the first place. It can therefore be argued that an inquiry into the particular content of the consumers' preferences can tap additional explanatory power. Such an inquiry means to go beyond the formal properties of preference orders and utility functions and to

develop hypotheses about the motivations underlying innovative consumer behavior. On the basis of an exemplary study – the historical innovations in a commonplace home production activity, the laundering of clothes – the present paper takes a step in that direction.

The example is significant for both the household production function approach and an extended motivation-theoretic approach. Regarding the former, the example invites one to explore the impact of rising real wages particularly for women who usually took care of the laundry. Rising wages raise the opportunity costs of using time for home production activities. Regarding the latter approach, the example points to a motivational conflict and suggests exploring the role of innovative products in solving it. At least under the conditions of what was called the "Blue Monday", personal cleanliness as a proximate motivation for doing the laundry conflicted with the motivation to avoid the strenuous ad painful work associated with it.

The paper proceeds as follows. Section 2 outlines the general motivational framework on which we draw and applies it to the considered home production activity. To be more specific with respect to the difference which the motivation-theoretic extensions make, Section 3 sets up a modal choice model familiar from household production theory. In a second step, the model is expanded so as to accommodate for the motivational aspects. Section 4 briefly summarizes the major changes that occurred in the home laundering technology. By putting them in perspective with the opportunity cost arguments on the one hand and the motivation-theoretic conjectures on the other a hypothesis about the factual relevance of the two explanatory approaches is derived. Section 5 turns to an empirical evaluation of the hypothesis. Direct information on the reasons that induced consumers to acquire an innovative washing machine is not available. We therefore try to reconstruct them from the content of washing machine advertisements extending over the period 1888 to 1989 in the U.S. This content reflects how the manufacturers perceived, and tried to appeal to, the consumers' motives for purchasing a washer in different historical contexts. Presuming that the manufacturers' perception is not systematically biased, the advertising data can be used to assess how the motivation-theoretic extension contributes to improving explanatory power. Section 6 concludes.

2. Substantiating the Assumptions on Consumer Preferences

For the past 150 years, four main stages can be distinguished in home laundering technology. They can roughly be characterized by the conditions of the "Blue Monday" for the initial stage. It is followed in turn by the stages of mechanization, electrification, and automation. [1] The historical sequence of diffusion processes of technically ever more advanced vintages of washing machines reflects the consumers' readiness to change their laundering behavior by buying new, innovative technology. How did this come about? What were the consumers' preferences – the preferences which the producers tried to account for with their innovative products? Instead of making ad hoc assumption at this point an attempt can be made to elaborate the motivational underpinnings of generic forms of behavior such as the laundering activities. Although preferences are highly subjective, there may be inter-personal similarities in what motivates such activities and the willingness to make changes in them. Such motivational similarities are especially likely in situations in which consumers are, or fear to be, exposed to deprivation in an important need. Such situations usually trigger a motivation to avoid, or escape from, deprivation by choosing proper action. [2]

In the example we investigate, the particular situation is the lack of cleanliness of one's clothes regarding visual dirt, odor, and germs. A related state of perceived or expected deprivation can emerge in several ways. It can be caused by fearing an infection or related pains from lack of hygiene. As has often been recognized (Cowan 1976, Matthews 1987,

[1] Technical change altered the way that clothes were cleaned not only with respect to the equipments used. It also changed the volume and frequency of the laundry and, as a consequence, the standard of physical and micro-biological cleanliness (Mokyr and Stein 1997, Shove 2003). Because of space constraints we focus here on the changing laundering technology.

[2] It has been argued that avoiding or reducing deprivation that way is an instance of what is called primary reinforcement in the theory of reinforcement learning (Witt 2001). Primary reinforcers are limited in number. With the usual interpersonal variance they influence behavior similarly across individuals, partly because of common genetic dispositions (see Leslie 1996, Chapter 6).

Shove 2003, Woersdorfer 2010), it can also result from fearing a loss of social standing should personal cleanliness fail to meet the socially accepted standard. Furthermore, it can be triggered by a dissonance between actual personal cleanliness and one's aesthetic self-image. The avoidance activity thus motivated is the laundering of the clothes. Obviously, a motivation to engage in laundering activities does not arise, if there is no deprivation perceived or expected. This is, for instance, the case if a lack of cleanliness is not recognized because of a low, socially approved standard of reference, or because the role of personal hygiene for preventing illness is not understood.

In terms of a utilitarian language these motivation-theoretic hypotheses suggest that laundering activities are a commonly shared source of utility, if they are perceived to be instrumental for avoiding infections and pains, loss of social standing, and/or loss of self-esteem. The contingency on the consumers' knowledge and perceptions is an important caveat. Scientific knowledge about germs as a health risk and the disinfecting effect of a regular laundry with hot water and soap did not emerge before the 19th century. The knowledge slowly propagated in the U.S. thanks to the Home Economics movement which promoted a scientific approach towards housekeeping (Cowan 1983; Mokyr and Stein 1997). Today consumer surveys show that in all developed countries at least a rough understanding of the relationships exists (see, e.g., SIFO 2003).

Similarly, consumer surveys today reveal that the respondents are aware of the fact that a high level of personal cleanliness is important for their social standing. For those consumers who share a preference for maintaining a positive self-image and for avoiding social disdain, (lack of) a certain level of personal cleanliness becomes a motivational force. Yet, an association of social recognition with a high level of personal hygiene was also only established during the 19th century (Mokyr 2000). This means that the standard regarding an acceptable (absence of) visual dirt and odor is not an absolute one, but contingent on the prevailing social convention. [3]

[3] See Mokyr (2000). Unlike the hygiene standard based on scientific evidence, the conventional level has continually been rising, pointing to an instability in the formation of the convention, see Woersdorfer (2010).

Given the laundering technology that was available to American households in the 19th century, their changing knowledge and growing motivation to clean their clothes created a dilemma for them. On the one hand they became aware of germs as a health risk and the possibility of reducing the risk by increasing their laundering efforts. On the other hand, doing the laundry at that time was consistently described as "the American housekeeper's hardest problem" (Beecher and Stowe 1869, p. 334) that one would hardly wish to face more often. The physically extremely exhausting work input connected with doing the laundry has been described as follows (see, e.g., Strasser 2000).

The laundry was usually done once a week on Mondays – "Blue Monday" – after clothes had been changed on Sunday. Water had to be carried and heated up in a wash boiler on the stove or on a fireplace in the backyard. The water necessary for the laundry – about fifty gallons weighing four hundred pounds – had to be hauled from the pump or well to the stove and tub, in buckets. At that time even well-to-do households did not have running water in their homes. The heated water was filled in a wooden tub to which soda and salt were added. Then the rubbing of the clothes on the scrub board started. (Invented around 1800, the scrub board epitomized the laundering "technology" for a whole century.) Next, the heavy, water-laden clothes and linens were wrung out, lifted to a wash boiler, and boiled on the stove while being agitated with a dolly. Clothes were wrung and rinsed several times, adding a blue agent to remove the yellow color of the soap – the agent inspiring the term "Blue Monday". Finally, the weighty wet laundry had to be brought outside and hung up on line to dry.

All this was strenuous and painful work not good for one's health. Obviously, a direct motivational conflict arose between reducing health risks from unclean clothes and increasing pain and health risks by cleaning the clothes. The same holds for the motivation to do justice to the rising social standard of cleanliness in order to support self-esteem and social standing. Put differently, the motivation to do the laundry met with a repugnant motivation to avoid or escape from the drudgery associated with the laundering activities. Under these conditions it can be conjectured that innovations promising to reduce or eliminate the drudgery associated with the laundry were likely to appeal to the consumers' preferences. This claim can be made more specific by recourse to a household production function model focusing on the laundering activity.

3. Response to Innovative Change in a Household Production Model

Since the seminal statement in Becker (1965), household production theory explicitly recognizes the time constraint which consumers face in addition to their budget constraint. (Assuming one-person households here, we use the terms "household" and "consumer" interchangeably.) Furthermore, the goods and services purchased in the market are interpreted as inputs. Combined with their time, the households use them to undertake their productive activities. Finally, it is claimed that the households derive utility not from the goods and services purchased in the market, but from the output of their activities. For what reasons utility is generated in this way is, however, left open. Does it make a difference if these reasons are specified on the basis of the motivation-theoretic hypotheses of the previous section? To discuss this question for the case of the laundering activities consider a modal choice version of the standard household production function model (see, e.g., Gronau 1986).

Let the home production function be given by

(1) $C = C\,(L_h, L_{mv}, X_c, T_c)$.

C, the average cleanliness of clothes, depends on the number of (standardized) full laundering cycles *L* per period. If done by hand, the $L_h > 0$ and $L_{mv} = 0$. If done with the help of a washing machine of vintage v, $L_{mv} > 0$ and $L_h = 0$. Three vintages can historically be distinguished by a significant new feature they embodied. A first vintage of washers ($v = 1$) were hand-powered mechanical devices supporting some of the laundry activities. The second vintage ($v = 2$) of washers substituted manual power by the electric motor in driving still the same or similar mechanical devices. The essential new feature added to the electricity-powered washing machines of the third vintage ($v = 3$) was their automation. X_c and T_c denote other market purchased inputs (detergents, water, heating energy, etc.) and time respectively for preparing and finishing the laundry (drying, ironing, etc.).

The different modes of doing the laundry involve in the one case a market purchased manual equipment (scrub board, tub etc.), X_h, and the corresponding time input T_h,

(2) $L_h = L_h\,(X_h, T_h)$.

In the other case, the used inputs are the washing machine of vintage *v*, X_{mv}, and the corresponding time input T_{mv},

(3) $L_{mv} = L_{mv}(X_{mv}, T_{mv})$.

Both X_h and X_{mv} are measured in utilization time as a share of total utilization over the life time of the corresponding equipments. Functions (2) and (3) are assumed to be monotonically increasing and invertible in both arguments.

Among the constraints under which the households choose the laundry mode is the one on the household's time

(4) $T = T_c + T_h + T_{mv} + T_o + T_w$.

T_w denotes paid working time and T_o time used in other household activities. The other constraint is the one on income. Income is made up of the wage income wT_w with w denoting the wage rate and the non-wage income V:

(5) $wT_w + V = p_c X_c + p_h X_h + p_{mv} X_{mv} + p_o X_o$.

p_j indicates the prices of the respective goods purchased on the market. Assuming for convenience a discount rate = 0, the product $p_i X_i,\ i = h, mv,$ gives the equipment or machine cost per wash. Inserting eq. (4) into eq. (5) and rearranging results in the total income constraint

(6) $wT + V = p_c X_c + wT_c + p_h X_h + wT_h + p_{mv} X_{mv} + wT_{mv} + p_o X_o + wT_o$.

Eqs. (1) – (6) represent a common frame for the two approaches whose implications are to be compared. The approaches differ in their hypotheses about the consumers' preferences and, hence, the utility functions. For the standard approach we follow Becker (1965) and assume that utility is derived from the output of the home production process. In our specific example, the variable *C* (cleanliness of clothes) thus enters the utility function. Other outcomes of the household's activities are for analytical convenience lumped together in a variable $Z_o = Z_o(X_o, T_o)$ so that

(7.1) $U_1 = U_1(C, Z_o)$.

In this approach, the arguments of the utility function are specified ad hoc, i.e. without recourse to a more elaborate motivational theory that explains why clean clothes should generate utility or why households should derive utility from the way in which they produce cleanliness.

In contrast, an extended approach based on the motivation-theoretic arguments in the previous section gives reasons for why cleanliness generates utility. Moreover, it suggests that, by these very reasons, an inherent conflict can arise in the production of clean clothes. The conflict is between enjoying the hygiene and social effects of clean clothes on the one hand and suffering drudgery in getting them clean on the other hand. It can be conceptualized as a trade off by entering L_h , L_{mv} as additional arguments into a utility function

(7.2) $U_2 = U_2(C, L_h, L_{mv}, Z_o)$.

In terms of the simple modal choice model this construction implies that overcoming the production conditions associated with "Blue Monday" is a source of own or direct utility.

Let the functions (7.1) and (7.2) be continuous and monotonically increasing in C, Z_o. Because of the "disutility" of drudgery, function (7.2) is decreasing in L_h and L_{mv} . As it appears empirically rather insignificant we abstract from the case in which disutility from drudgery outweighs utility from cleanliness so that no laundry is done at all. We then obtain:

Proposition

In the standard approach, the necessary condition for a utility maximizing household, currently doing the laundry by hand, to change its laundering technology by buying a washing machine of vintage v is that in the current optimum

(8.1) $$\frac{\frac{\partial U_1}{\partial C}\left(\frac{dC}{dL_{mv}}\right) - \frac{\partial U_1}{\partial C}\left(\frac{dC}{dL_h}\right)}{\lambda} - \left(p_{mv}\frac{\partial X_{mv}}{\partial L_{mv}} - p_h\frac{\partial X_h}{\partial L_h}\right) - w\left(\frac{\partial T_{mv}}{\partial L_{mv}} - \frac{\partial T_h}{\partial L_h}\right) > 0 .$$

In the extended approach the necessary condition is:

$$(8.2)\quad \frac{\frac{\partial U_2}{\partial C}\left(\frac{dC}{dL_{mv}}\right) - \frac{\partial U_2}{\partial C}\left(\frac{dC}{dL_h}\right) + \left(\frac{\partial U_2}{\partial L_{mv}} - \frac{\partial U_2}{\partial L_h}\right)}{\lambda} - \left(p_{mv}\frac{\partial X_{mv}}{\partial L_{mv}} - p_h\frac{\partial X_h}{\partial L_h}\right) - w\left(\frac{\partial T_{mv}}{\partial L_{mv}} - \frac{\partial T_h}{\partial L_h}\right) > 0.$$ [4]

The difference between conditions (8.1) and (8.2) is the term $\left(\frac{\partial U_2}{\partial L_{mv}} - \frac{\partial U_2}{\partial L_h}\right)/\lambda$ in (8.2) representing the "disutility" of drudgery. It points to the fact that in the extended approach a utility gain from switching can also be caused by a changing amount of physical strain associated with each laundering cycle carried out.

The implications of the Proposition for a positive response of the households to innovations in laundry technology can be summarized by two corollaries.

Corollary 1 (time substitution hypothesis)

> *For* $\frac{\partial T_{mv}}{\partial L_{mv}} - \frac{\partial T_h}{\partial L_h} < 0$ *condition (8.1) is the more likely satisfied the higher w and/or the greater the marginal time saving per laundering cycle done by a new vintage of washers over doing the laundry by hand.* [5]

Corollary 1 reproduces the prediction of household production theory: "A rise in the cost of time relative to goods would induce a reduction in the amount of time and an increase in the amount of goods used per unit of each commodity" (Becker 1965, p.513). The cause of the substitution – effected by the purchase of a washing machine – is identified with increasing opportunity costs of the time-intensive doing the laundry by hand. The rising opportunity costs are explained by the historical increase in *w*, the wage rate particularly for female labor. (Women have for the most part been doing the laundry for the family so that it is foremost their time that could be saved.) However, the relevance of this explanation has been questioned

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4 For a proof see the Appendix.

5 For a discussion see the Appendix.

based on the observation that changes in home production occurred already before the wage rate particularly for female labor rose, see Vanek (1974), Bowden and Offer (1994), Bianchi et al. (2000).

Adding further reservations, condition (8.1) reveals that, even if there were changing opportunity costs of time, these would not be sufficient to bring about the predicted substitution. It is also necessary that time savings become technically feasible, i.e. that the term $\frac{\partial T_{mv}}{\partial L_{mv}} - \frac{\partial T_h}{\partial L_h}$ becomes negative *and,* in absolute terms, sufficiently large. It remains to be seen to what extent and when this additional condition has been satisfied historically. If either the opportunities costs of time use or technical feasibility of time savings did not change, the willingness to acquire a washing machine of a new vintage and the corresponding changes in home production have to be explained differently. The extended approach offers an explanation as follows.

Corollary 2 (drudgery reduction hypothesis)

> *For* $\frac{\partial T_{mv}}{\partial L_{mv}} - \frac{\partial T_h}{\partial L_h} \leq 0$ *condition (8.2) is the more likely satisfied the smaller* $\left| \frac{\partial U_2}{\partial L_{m2}} \right|$.
> *For* $\frac{\partial T_{mv}}{\partial L_{mv}} - \frac{\partial T_h}{\partial L_h} < 0$ *condition (8.2) is the more likely satisfied also the higher w and/or the greater the marginal time saving per laundering cycle done by a new vintage of washers over doing the laundry by hand.* [6]

Corollary 2 suggests that, while purchases of washers may be motivated by substituting working time for time in household production, this is not the only possible motive. To get relief from the drudgery associated with doing the laundry by hand is another and, in the absence of significant time savings or a rising wage rate, possibly the only motive. It again remains to be seen, however, whether and when the technical prerequisites for such a relief emerged. This means that the conditions relevant for the time substitution hypothesis and the drudgery reduction hypothesis need to be put in perspective with the changing characteristics

[6] For a discussion see the Appendix.

of the home laundering technology. Accordingly, the next section focuses on the technical change in that technology.

4. Changes in the Home Laundering Technology as an Explanatory Contingency

The first major innovations (v = 1) that appeared on the market during the second half of the 19th century were mechanical devices that imitated the pulling, pressing, and rubbing of clothes (see, e.g., Buehr 1965). Early examples are rotary-type washers consisting of a large drum turned by a handle; manual rocking scrub boards; revolving paddles inside a boxlike tub that were turned by a crank; mechanical 'dollys' driven by rotating a lever or a flywheel gear to agitate the clothes in a tub. There were also other techniques available to create suction and pressure, for instance, the vacuum wash plunger. Later on, two-tub washers were introduced. The inner, perforated tub held the clothes, the outer tub was filled with water. Through the holes in the inner tub, water was forced through the laundry, when the inner tub was rotated. [7] All these mechanical devices were hand powered so that substantial physical effort was still necessary for running them. They were better, however, at keeping the hands clear of the painful contact with hot and soapy water. The time savings made possible, if any, were not substantial, though the subjective perception of these savings may have been different.

The second wave of innovations was triggered by the electrification of urban homes at the beginning of the 20th century. This created opportunities for washing machines powered by electricity (v = 2). By the mid 1920s two designs of the electric washing machine had become dominant. One was the electric agitator derived from the dolly principle. The other was the principle of the perforated metal cylinder – arranged horizontally as a front-loader – in which clothes were tumbled when it rotated in an outer tub containing the suds. By both designs,

[7] According to Giedion (1948, p. 550), by 1873 no less than some 2000 U.S. patents on mechanical laundering devices had been granted. An additional innovation were primitive manual wringers that eased the drying of clothes with the help of leverage power. Garments were run through two parallel rollers which were moved by turning a spring.

moving and rubbing of the laundry could be intensified. Together with improved detergents introduced at the same time this meant improved cleanliness of the washed clothes. [8]

The electric motor driving the mechanical devices formerly powered by hand meant a breakthrough regarding the relief from strenuous physical work. However, the machines continued to require considerable personal attendance for operating and controlling the various steps of the washing cycle. They therefore brought only modest time saving. Despite problems with safety and increased mechanical wear and tear caused during the laundering of the clothes, the new technology successfully diffused in the market. According to Lebergott (1993, p. 115), a quarter of American households had already acquired an electric washing machine by 1930. Bowden and Offer (1994) estimate that of the 80% of American households that had electricity at home in 1941, about 60% possessed some kind of electric washing machine, i.e. roughly one half of all households.

The third innovative wave that transformed the washing machine into what is the dominant design up to the present occurred in the mid 1940s with the automation ($v = 3$). First mechanical clockworks, later electronic controls, were built into the machines to actuate the sequence of operations and their timing. The washing and spin-drying functions were integrated. Both could then automatically be carried out in sequence within the same tub. The technical innovations were built into front-loading machines or top-loading machines like the popular Bendix automatic washer and Thor "automagic" washer of the 1950s. Enclosed in enameled rectangular cabinets of white color both had a shape that appears familiar today. With the automated machines, the home maker could save the time for operating and controlling the various steps of the washing cycle. Sequence, duration, and temperature could be adjusted by pre-programming the machines. Special programs were developed that accounted for fabric, color, dirt, and the size of the load of washed clothes. All that was left to be done for the homemaker was sorting clothes, loading the machine, adding detergent,

[8] Another important improvement due to electrification was the replacement of the manual wringing out of textiles by spin-dryers empowered by an electric motor. Many manufacturers combined washers and spin-dryers within the same chassis and powered them by two separate electric motors with different speeds (Giedion 1948, p. 569).

choosing the appropriate program, unloading the machine and drying the clothes further. Doing the laundry now meant a negligible physical effort and a minor toll on the homemaker's time. [9]

The different vintages thus offered quite different opportunities for saving time on the one hand and avoiding drudgery on the other. The mechanized washers (v = 1) were comparatively expensive. According to Strasser (2000, p. 116) their prices ranged from $ 2.50 to $ 4.25 at the end of the 19th century as compared to only 20 cents for a scrub board. Moreover, they led to only minor time savings. Whether they were subjectively perceived as sufficiently momentous to motivate the purchase of a washer is questionable. The modest reduction of physical strain that became feasible may have been important. Yet, judged by the relative share of adopters of this technology, it was apparently not a very powerful motivation for acquiring a washer. Lebergott (1993, p. 115) estimates that in 1900 only 1% of all American households owned a mechanical washer.)

The electrification (v = 2) brought substantial reductions of strenuous physical work and modest time savings as compared to doing the laundry by hand or by hand-powered, mechanical devices. The time savings may subjectively have been held significant by the household in those years. In view of the more spectacular drudgery reduction effect it does not seem plausible though that they were the more important, or even the only, reason for purchasing a washing machine as the time substitution hypothesis suggests. It was only by automation (v = 3) that home makers could realize substantial time savings. But these machines no less freed the home makers from strenuous physical work, if the laundry had formerly been done by hand or by hand-powered, mechanical devices. The motivation to reduce drudgery may therefore still have been relevant for buying a washer of the third vintage.

[9] Later innovations had little impact on the laundering activities as such. These were lighter and more durable materials, noise and vibration reductions, increased load capacity and spin speed, semi-conductors and electronic touch controls, and, most recently, improvements in energy and water conservation. Along with all the innovations average household expenditures on washing machines rose. Lebergott (1993, p.116) estimates the share of annual income spent on laundry equipment as the equivalent of a day's pay in 1900 as compared to the equivalent of two or three weeks' pay in 1990.

The chronology of the technical changes thus seems to condition the explanations of innovative consumer behavior suggested by the two explanatory approaches. The first two vintages of washing machines could be sold to households in the U.S. at a time when female labor force participation rates were still rather low (see, e.g., Costa 2000) and before the wage rate for women started to rise significantly in the 1940s. Moreover, time savings made possible by the first two vintages were modest at best (although they may have subjectively been considered significant). Under these conditions, saving time on doing the laundry and making better use of it otherwise can hardly be expected to be a dominant or even the only reason explaining the purchases of washing machines

Unlike the time substitution hypothesis, the extended approach draws attention to an additional reason: the motivation to reduce physical strain. It may be argued to be equally or even more important for explaining the success of the early vintages of washing machines. But this motivation may also have contributed significantly to purchases of innovative washing machines when they eventually made significant time savings possible. In fact, this motivation is independent of whether or not rising opportunity costs of household time have an effect as claimed by the time substitution hypothesis. [10] For an empirical assessment of the two approaches their theoretical predictions can be summarized as follows:

Test Hypothesis:

> *(i) Time saving is not a dominant or even the exclusive reason for purchasing a washer of the first and second vintages; drudgery reduction is at least as important a reason. (ii) Drudgery reduction continues to be an equally important reason even for buying an automatic washing machine as long as it replaces doing the laundry by hand or by a hand-powered mechanical device.*

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[10] It has been observed that families with working wives and families with non-working wives show no systematic differences in terms of ownership of washing machines, see Strober (1977), Weinberg and Winer (1983), Nickols and Fox (1983). This observation seems incompatible with the time substitution hypothesis while it would be compatible with the drudgery reduction hypothesis.

5. Empirical Evidence: Drudgery Reduction vs. Time Substitution

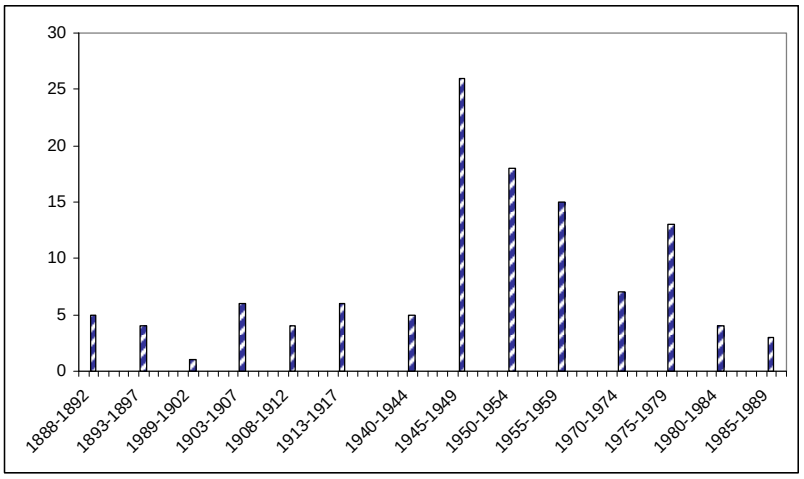
An empirical evaluation of the test hypothesis requires identifying first what reasons consumers have for buying a washing machine. Moreover, how do these motivations change over time? There are no historical surveys or opinion polls from which relevant information could be drawn. The reasons must therefore be reconstructed on the basis of other information sources. The source we use are historical advertisements of the manufacturers of washing machines. The underlying assumption is the following. When a particular laundering technology is still new and consumers need to be familiarized with it, manufacturers have strong incentives to advertise reasons why it should be desirable to adopt the new technology. Accordingly we assume that the manufacturers anticipate the most important reasons in a way that is not systematically biased with regard to the test hypothesis and try to appeal to them in their ads.

In view of the hypothesis to be tested, we focus particularly on information that points to drudgery reduction and time saving as reasons given in the ads for buying a washing machine. Ads whose content reflects other motives or an entirely different advertising strategies – like, e.g., establishing positive associations with a particular brand name – are subsumed under a residual category. The advertising medium we have scanned is the *Ladies' Home Journal.* Published since 1883 and still issued today by the Curtis Publishing Company of Philadelphia it has been one of the most popular American women's magazines. It has appeared on a monthly basis for most of its existence and already reached a circulation of 1 million at the beginning of the 20th century (Fox 1990). [11] Given these facts it may be considered a representative source for washer ads.

[11] The content of this journal is often referred to in historical narratives of the aspirations, ideals, and tools with which housework has been carried out in the U.S., see, e.g., Cowan (1976), Matthews (1987), Strasser (2000). However, with the exception of Fox (1990) who analyses a question different from ours with a sample smaller than ours, quantitative analyses of the content of advertisements have to our knowledge not been done.

Since there is no reason to assume that the content of the washer ads varies systematically with the monthly issues, we have confined our sample to the June and November issues to keep the data collection manageable. These issues cover the special "June brides" and the festivities of Thanksgiving and Christmas respectively and therefore tend to contain more ads. The years covered by the sample are 1888-1919, 1940-1960, and 1970-1989, i.e. altogether 70 years. These sample periods were chosen to account for the sequence of diffusion processes of the three vintages of laundering technology. For each issue studied, the following pieces of information were collected: (i) total number of ads per issue; (ii) number of ads for washing machines per issue; (iii) size of the advertisements; (iv) information on drudgery reduction, time saving, or other motivations to buy a washer in the content of the ads; (v) the technical characteristics of the advertised washers; (vi) brand and manufacturer of the advertised washing machine. [12]

Fig. 1: Time distribution of washer advertisements



Source: June and November issues of Ladies' Home Journal.

The first ads on washing machines that we found date back to 1889, i.e. almost to the very beginning of our dataset. The intensity with which this product has been advertised in the *Ladies' Home Journal* varies considerably over time. The peak occurs in the post-WWII period. The number then flattens during the 1980s (Fig. 1). The number of washer ads peaked

[12] Access to the scans and transcripts of the texts of the sampled advertisements can be made available on request.

not only in absolute terms during the years 1945 to 1959, but also in its share in all advertisements in the issues of the *Ladies' Home Journal* we inspected.

To categorize the ads with respect to what kind of motivation they were appealing to, we classified their content into three categories: drudgery reduction, time saving, and a residual category of other motives. A sample of representative expressions we found in the ads is given in Table 1. For most of the ads it was not difficult to decide what motives were present. In cases where both motives were simultaneously alluded to or where very general terms were used such as "it saves work" or "you only push a button" we interpreted the ad as contributing with one half of their size to each of the two motives. Hints in the ads that a washing machine would make domestic servants and washerwomen superfluous were also coded as appealing to the motive of drudgery reduction.

Table 1 Categorizing Advertisements with Regard to Consumer Motives: Examples

Motive of drudgery reduction	*Motive of time saving*
◊ "will save you labor"	◊ "will save you time"
◊ "does away with all the drudgery"	◊ "waste not your time"
◊ "waste not your strength"	◊ "twice as rapidly"
◊ "not back straining"	◊ "washes in as little as an hour"
◊ "turning slavery of washday into real comfort"	◊ "does washing of an ordinary family in one hour"
◊ "operate without exertion"	◊ "half the time old washers need"
◊ "take the hard work out of the washday"	◊ "great time saver"
◊ "save your muscular effort"	◊ "washes quicker"
◊ "you never lug laundry again"	◊ "no supervision"

The advertisements for the washing machines also contain information on technical features. This information can be used for determining at what time what vintage of washers has

been advertised as innovative laundering technology. Table 2 gives the shares for the different power sources and the share of automatics among the advertised washing machines as averages per observation period. As can be seen, hand-powered machines (v = 1) dominate the advertisements for the period 1888-1919. However, the share of washers with an electric motor (v = 2) rapidly started to dominate the ads from the 1910s onwards. At that time, electricity became available as a power source in the urban areas of the U.S. Hence, the transition from v = 1 to v = 2 can be dated to the last third of our first sample period, i.e. to 1910-1919). In the period 1940-60 ads for the hand-powered devices have disappeared completely. Moreover, the share of ads for fully automated machines (v = 3) quickly increases. Towards the end of that sample period they make up the majority of ads for washing machines. We therefore infer that the transition from v = 2 to v = 3 takes place between 1940 and 1960. Indeed, in the years 1970-89 none of the ads showed machines of earlier vintages anymore.

Table 2 Shares of Power Sources and of Automated Washers in the Advertisements

	Power Source				
Period	*Manual*	*Electricity*	*Water*	*Steam*	Automatic
1888-1919	0.48	0.39	0.10	0.03	0
1940-1960	0	1.00	0	0	0.64
1970-1989	0	1.00	0	0	1.00

Table 3 shows the descriptive statistics for ads during the three sample periods classified by the categories drudgery reduction ("DR"), time saving ("TS"), and "other". We further distinguish them by their size, taking this as an expression of prominence or emphasis a manufacturer attaches to the content of the advertisement. For the years 1888-1919, i.e. for the first two vintages of washers, DR (54%) clearly exceeds TS (38%) in terms of the size-weighted share of the categories in the entire sample of washer ads. The category "other" has only a small share (8%). With respect to part (i) of the test hypothesis it can be inferred that time saving is not

a dominant or even the exclusive reason for purchasing a washer. Drudgery reduction is at least as important a reason.

Table 3 Drudgery Reduction, Time Saving, and Other Motives in Washer Ads by Ad-Size

Size of ad in pages	1888-1919			1940-1960			1970-1989		
	Number of ads with motives			*Number of ads with motives*			*Number of ads with motives*		
	DR	TS	other	DR	TS	other	DR	TS	other
Less than ⅛	8	6	2	1	3	2	0	0	0
⅛ to less than¼	4	3	0	1	2	0	0	0	0
¼ to less than ½	4	2	1	1	3	1	0	0	0
½ to less than 1	1	1	0	6	10	1	1	4	1
1 to less than 1½	0	0	0	15	15	7	0	1	21
1½ to less than 2	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	1	0	0	0
Share of ads weighted by size per period	0.54	0.38	0.08	0.38	0.45	0.17	0.02	0.15	0.83

DR = drudgery reduction, TS = time saving

As we inspect only a random sample of motives given in two issues of the *Ladies' Home Journal* per year, the question arises whether this conclusion can be inferred to be valid also for the unknown distribution of motives in all advertisements. To answer the question we test the null hypothesis that for the period 1888-1919 the empirical size distribution of DR-ads in Table 3 is drawn from the same, unknown distribution as the empirical TS-distribution. If the null hypothesis cannot be rejected, part (i) of the test hypothesis cannot be refuted for the entire set of advertisements in that period. Thus we calculate maximum likelihood estimators for the unknown true frequencies of ads of different size for DR and TS from the empirical ones on the

basis of a log-linear model. Applying a χ^2-test to the two estimated frequency distributions we cannot reject the null hypothesis at a reasonable significance level. Hence it can be inferred that, in the advertisements in this period, drudgery reduction is at least as important a motive for purchasing a washing machine as time saving is.

Part (ii) of the test hypothesis refers to the period 1940-1960 during which the automated washers of the third vintage penetrate the market. For that period it is claimed that drudgery reduction continues to be an a motive for purchasing washing machines that is equally important reason as the time saving motive. Table 3 shows that, in terms of the size-weighted share of the motives in the entire sample of washer ads, DR (38%) and TS (45%) have changed places in comparison to the period 1888-1919. The category "other" (17%) has more than doubled its share. For a statistical inference we again test the null hypothesis that the empirical size distribution of DR-ads in Table 3 is drawn from the same unknown distribution as the empirical TS-distribution. If the null hypothesis cannot be rejected, part (ii) of the test hypothesis cannot be refuted for the entire set of advertisements in that period. Applying the same estimation and test procedure as before, this null hypothesis too cannot be rejected at a reasonable level of significance. Time saving is still not a dominant or even the exclusive reason for purchasing washing machines in the advertisements in this period.

After automated washing machines had fully captured the market in the early 1960s, the content of the ads changed completely in the period 1970-1989. As the last column of Table 3 shows, the lion's share of the size-weighted ads is now classified as serving other motives or advertising strategies (83%). Most of them represent attempts to build up and strengthen brand names in washing machines. The shares of TS (15%) and DR (2%) are of minor importance or negligible. Since it is unlikely that an automatic washer bought in this period replaces doing the laundry by hand or by a hand-powered mechanical device, the disappearance of the drudgery reduction motive is not incompatible with the test hypothesis. The "bugaboo of the Blue Monday" (as it was put in an early ad) has been forgotten. The capacity of washing machines to eliminate drudgery from doing the laundry has become a matter of course.

6. Conclusions

In this paper we have discussed two approaches to explaining innovative behavior on the part of consumers. The example we used is that of the technically ever more advanced vintages of washing machines. They conquered the market in turn over more than a century and successively revolutionized households' laundering activities. Why and when have consumers been willing to buy these machines? Most economists agree that the consumers' preferences play a decisive role. Yet, the conclusions that can be drawn from this tenet differ a lot. One of the discussed approaches to explaining the consumers' adoption of new laundering technology has been suggested by household production theory. In this theory, the assumptions about the consumers' preferences are specified in an ad hoc fashion. The explanation is focused on changes in the constraints, in particular the changing opportunity costs of time resulting from a rise in real wages. The replacement of time intensive laundering activities by machine-supported, time saving ones is in this way subsumed under the well known time substitution hypothesis.

However, the reason why an innovative consumption good (as the washing machine once was) succeeds in the market can also be a particular preference of the consumers which the new product is able to satisfy. In that case, a parsimonious treatment of the consumers' preferences as in standard household production theory is not enough. It is necessary to explain what relevant preferences there are and for what reasons they motivate the purchase of a washing machine of a particular vintage. Following such an approach we have taken steps to elaborate the relevant motivation-theoretic underpinnings of consumer behavior. By recognizing how American households had to do the laundry in the 19th century, it became apparent then that a growing motivation to clean their clothes conflicted with the aversion against physically strenuous work which doing the laundry meant at the time. From this conflict it can be inferred that the way of doing the laundry can itself generate utility. This conjecture led to what we have called the drudgery reduction hypothesis for explaining the purchase of washing machines.

To empirically evaluate the two different hypotheses it is necessary to identify the reasons that motivated the consumers to buy the different vintages of the washing machine. Since consumer survey data covering a whole century are not available, we have constructed a data set based on the content of washing machine advertisements over the period 1888 to 1989. Our assumption was that the content reflects how the manufacturers perceive the consumers' motives underlying the purchase of a washer and how they try to appeal to them in different historical contexts. Regarding the empirical test, it turned out that the different motives for buying a washer seem to be conditioned by the (changing) technical properties of the washing machines. In the case of the time substitution hypothesis the crucial condition is that a washing machine allows the user to indeed save time (that can also be used more effectively otherwise). In the case of the drudgery reduction hypothesis, the use of a machine must relieve the homemaker from some strenuous or painful actions that were previously necessary. It can be expected that, in their ads, the manufacturers started to appeal heavily to motives for buying a washer for which their products have met the preconditions.

Based on this expectation we have analyzed the relevant technical information in the advertisements. As substantial time savings became technically feasible only with the last vintage of washing machines, we have argued that time saving cannot be assumed to be a dominant or even the exclusive reason for purchasing a washer of the first and second vintages. The early machines allowed the home makers to significantly reduce strenuous and painful parts of the laundering activity. For this reason we have assumed that the motivation to reduce drudgery, to which the extended explanatory approach drew attention, was at least as important a motive for buying an early washer as the time saving motive was. Furthermore, we have argued that drudgery reduction continued to be a motive equally important as the time saving motive even for buying a washing machine of the third vintage – as long as it replaced doing the laundry by hand or by a hand-powered mechanical device. To empirically evaluate these conjectures, we tracked the changing frequencies with which drudgery reduction, time saving, and other motives appeared in the advertisements in the course of time. The statistical evidence we found confirms all the conjectures. We take these findings as evidence for the claim that reflections on the content of the consumers' preferences can indeed improve the explanatory power of economic theory.

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Appendix

Proposition 1 follows from taking partial derivatives of a Lagrangian function based on eqs. (6) and (7.1). The resulting first order condition for a constrained utility maximum in case of the hand laundry is

$$\left(\frac{\partial U_1}{\partial C}\frac{dC}{dL_h}\right) / \lambda = p_h \frac{\partial X_h}{\partial L_h} + w \frac{\partial T_h}{\partial L_h}.$$

λ is the Lagrangian multiplier representing the marginal utility of income. The r.h.s. of the equation is the shadow price of one unit of output of the laundering activity. Assuming that the second order condition is satisfied, the utility maximum is reached at a level of cleanliness $C_h^* \geq 0$. Given that the relevant functions are continuous and monotonically increasing, the necessary condition for buying a washing machine and doing the laundry with its help is

$$\left(\frac{\partial U_1}{\partial C}\frac{dC}{dL_{mv}}\right)_{|\,C=C_h^*} / \lambda > p_{mv}\frac{\partial X_{mv}}{\partial L_{mv}} + w\frac{\partial T_{mv}}{\partial L_{mv}}.$$

This implies that at the value $C = C_h^*$ the constrained utility maximum for the machine-based laundering activity has not yet been reached. Taking both conditions together results in the inequality (8.1).

When using eq. (7.2) in the Lagrangian, the first order condition for a constrained utility maximum in case of the hand laundry is

$$\left(\frac{\partial U_2}{\partial L_h} + \frac{\partial U_2}{\partial C}\frac{dC}{dL_h}\right) / \lambda = p_h \frac{\partial X_h}{\partial L_h} + w \frac{\partial T_h}{\partial L_h}.$$

Since we abstract from the case in which disutility from drudgery would outweigh utility from cleanliness, the l.h.s. of the equation is positive and an optimal level of cleanliness $C_h^* \geq 0$ exists. The necessary condition for switching from hand laundry to machine laundry is then analogously

$$\left(\frac{\partial U_2}{\partial L_{mv}} + \frac{\partial U_2}{\partial C}\frac{dC}{dL_{mv}}\right)_{|C=C_h^*} - \lambda \; > \; p_{mv}\frac{\partial X_{mv}}{\partial L_{mv}} + w\frac{\partial T_{mv}}{\partial L_{mv}}.$$

Taking both conditions together results in the inequality (8.2).

Corollary 1 follows from the size and sign of the summands on the l.h.s. of condition (8.1). Depending on *v*, the term $\frac{\frac{\partial U_1}{\partial C}\left(\frac{dC}{dL_{mv}}\right) - \frac{\partial U_1}{\partial C}\left(\frac{dC}{dL_h}\right)}{\lambda} \geq 0$. Since, in the light of the available price information, $\left(p_{mv}\frac{\partial X_{mv}}{\partial L_{mv}} - p_h\frac{\partial X_h}{\partial L_h}\right) > 0$, it depends on the relative size of the first two summands whether the difference between them is positive. The product $w\left(\frac{\partial T_{mv}}{\partial L_{mv}} - \frac{\partial T_h}{\partial L_h}\right) < 0$ for $w > 0$ if, for a given *v*, $\frac{\partial T_{mv}}{\partial L_{mv}} - \frac{\partial T_h}{\partial L_h} < 0$. Condition (8.1) is therefore the more likely satisfied, the higher *w* and/or the greater the marginal time saving per laundering cycle done by a new vintage of washers over doing the laundry by hand.

Corollary 2 follows from the size and sign of the summands on the l.h.s. of condition (8.2). Since, as a result of technical changes, $\frac{\partial U_2}{\partial L_h} \leq \frac{\partial U_2}{\partial L_{mv}} < 0$, $\frac{\partial U_2}{\partial L_{mv}} - \frac{\partial U_2}{\partial L_h} \geq 0$ and the greater, the smaller is $\left|\frac{\partial U_2}{\partial L_{m2}}\right|$ independent of whether or not $\frac{\partial T_{mv}}{\partial L_{mv}} - \frac{\partial T_h}{\partial L_h} = 0$. Since all other summand on the l.h.s. of condition (8.2) are identical to those in condition (8.1) it follows that, condition (8.2) is the more likely satisfied the smaller is $\left|\frac{\partial U_2}{\partial L_{m2}}\right|$ *and* the higher *w* and/or the greater the marginal time saving per laundering cycle done by a new vintage of washers over doing the laundry by hand.

Appendix for the referee (not for publication)

Test of the null hypothesis pp. 20-1 in Section 5:
The positive entries in the DR column and the TS column in Table 3 for the period 1888-1919 are interpreted as a 2 x 4 contingency table

motive	mean page size				totals
	1/16	3/16	6/16	12/16	
DR	8	4	4	1	17
TS	6	3	2	1	12
totals	14	7	6	2	29

The maximum likelihood estimators for each cell (based on a log-linear model) are calculated by multiplying the corresponding row totals with the column totals and dividing by the grand total resulting in

8.2 4.1 3.5 1.2

for the cells in the first row and

5.8 2.9 2.5 0.8

for the cells in the second row. Correspondingly, we calculate

$$\chi^2 = \frac{(8-8.2)^2}{8.2} + 0.002 + 0.07 + 0.03 + 0.007 + 0.003 + 0.1 + 0.05 = 0.465$$

The critical value of the χ^2 – distribution with 3 degrees of freedom at a significance level of 0.1 is 6.251. Since $0.465 < 6.251$ the null hypothesis cannot be rejected at that significance level.

The positive entries in the DR column and the TS column in Table 3 for the period 1940-60 are interpreted as a 2 x 5 contingency table. The further calculations are carried out analogously. The result is $\chi^2 = 2.03 < 7.779$, where 7.779 is the critical value with 4 degrees of freedom at a significance level of 0.1. Again the corresponding null hypothesis cannot be rejected at a 0.1 significance level.