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CONSUMPTION IN POLISH HOUSEHOLDS - PRODUCTION FUNCTION PARAMETERS AND MONETARY VALUE OF NON-MARKET GOODS

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ABSTRACT. The aim of this paper is to estimate the parameters of the household production function as well as assessing the monetary value of the goods and services produced. The existence of jointness seems to be supported not only by sheer intuition, but also by the results of the calculations presented in this study. In order to supplement the statistical material included in the time-use database, data from the surveys on household budgets as well as remuneration structure by occupation were used. The results of the present study are similar to the findings published in other articles in the respect that market goods as inputs in the production process have been found to play a greater role in determining its value than the time spent by spouses. Thus, in the vast majority of cases, the elasticity of production relative to market goods is clearly greater than its elasticity in terms of time expenditure. So, if material inputs in household production are the function of their earnings, the latter will be one of the most important factors differentiating the value of the non-market production outputs of individuals.

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Introduction

The development of research within the so-called "new home economics" was hindered from the very beginning by the lack of access to appropriately detailed data. For a long time economists generally did not deal with the non-market sphere, and the management of scarce resources that occurs there, due to the fact that since the emergence of economics as

a scientific discipline little effort was made to quantify this sphere of human activity. The household production function (HPF) model, which together with the theory of time allocation, proposed by Becker (1965) and subsequently modified by Gronau (1973, 1977), turned out to be a concept that at the same time contains guidelines for the empirical verification of findings. Additionally, the fact that time-use surveys have begun to be implemented in an increasing number of countries, and that the comparability of databases of this type has significantly increased, has been an impulse for a wave of empirical prediction tests based on the HPF model.

A significant problem from the viewpoint of empirical analysis using the HPF model is information related to the quantity and the value of goods produced in households (Kooreman & Kapteyn, 1987). They do not produce the kind of reports that companies do, which would be a valuable source of data (Lützel, 1989). One of the ways of estimating the value of goods and services produced in households is through estimating the parameters of the production function. However, the possible forms of such functions have still not been determined (Gronau & Hamermesh, 2003). It is worth noting that in general certain phenomena or processes, such as increasing utility as a result of consumption, have escaped objective measurement, regardless of whether they take place in the market sphere or outside it. Therefore, for example, analysing the impact of changes in tastes and, separately, production technologies on consumer behaviour, turns out to be very problematic.

Another issue that hinders empirical analyses referring to the theory of the household production function is shortage of data on time allocation that would also contain information on the income, expenditure and consumption structure of a given population (Ahn et al., 2003). Even access to specific types of information from various research samples obtained in the same time period is limited to a few countries only (Gronau & Hamermesh, 2003).

In view of the abovementioned difficulties, empirical analyses using the HPF concept are usually restricted to value estimation of home production and the description of the increase in utility in an indirect way, only on the basis of the inputs in the production process. Consequently, one of the basic problems is quantitative description of the production process which occurs in households (Kerkhofs & Kooreman, 2000).

The aim of this paper is to estimate the parameters of the household production function as well as estimating the monetary value of the goods and services produced. To achieve this aim, the authors refer to the methodology proposed by Graham and Green (1984), modifying it according to the availability of the appropriate statistical material under Polish conditions. In order to supplement the statistical material included in the time-use database, data from the surveys on household budgets as well as remuneration structure by occupation were also used.

The paper is organized as follows: section 2 presents a brief overview of the analyses aimed at estimating the parameters of the production function and measuring the monetary value of goods and services produced in the non-market sphere; section 3 contains a description of the statistical material and the methodology used; section 4 presents the results of estimations; and the final section consists of discussion and conclusions.

1. Examples of estimation of the production function parameters and valuation of the obtained output

Gronau (1977, 1986), who observed a significant drawback in Becker's theory, introduced a significant modification to the model. He argued that the HPF theory may offer more accurate predictions about consumer decisions if activities in the non-market sphere are clearly divided into production and consumption (leisure). The proposed modification created

the possibility of using data on the time-use of households and significantly facilitated the empirical verification of predictions obtained using the modified version of the HPF model.

Another important change introduced by Gronau was a redefinition of the outputs of home production, describing them as products that are very similar to the goods and services which can be purchased on the market (Apps & Rees, 2009). As a result of his assumptions, Gronau abandoned the abstract construct of a commodity proposed by Becker, referring to goods and services in the ordinary sense as close (or even perfect) substitutes for those offered on the market.

Gronau, who was one of the first to attempt to estimate the value of home production, used marginal productivity of the home production function in the semi-log form for this purpose (Gronau, 1980). In his work, he highlighted the basic problems associated with such estimations. In the case of households, it is not only the output of their production that is not known (Z), but it is not even possible to accurately divide the purchased market goods into those that are directly consumed and those that are used as inputs in the process of home production. Therefore, the author argued that in such a situation the value of the production should be estimated indirectly. In a multi-stage calculation procedure, he included such socio-economic characteristics as the wife's age and education, the husband's education and wage rate, the family's non-earned income, the number of children, the age of the youngest child, and the number of rooms in the house (Gronau, 1980).

Increased interest in using the Cobb-Douglas production function in empirical research was triggered, among other things, by the publication of Farrell's paper in 1957 (Farrell, 1957; Battese, 1992). Originally used for the analysis of production in enterprises, it was later also applied within the framework of the theory of the household production function. A convenient and thus frequently used solution in this case is the assumption of constant returns to scale (Blaug, 1995).

In 1984 Graham and Green proposed a method of estimating the household production function parameters according to the Cobb-Douglas approach. In their study, the authors referred to Gronau's model, but they reduced its restrictiveness as far as assumption about the occurrence of the joint production phenomenon is concerned (Graham & Green, 1984).[1] According to accepted view, part of the time devoted to household work can be treated as leisure time (consumption). The authors formulated three goals: estimating the parameters of the Cobb-Douglas production function; estimating the value of home production; and determining the extent to which the time spent on household work provides direct utility to people. The calculations were performed on a sample of 921 married couples, in which both partners worked.

The modified assumptions of the HPF model widened the range of its possible implications, which brought the results closer to the actual decisions that are made in households (Kerkhofs & Kooreman, 2003). Apart from offering benefits in the form of more diverse solutions, relaxing the assumptions of Gronau's model also resulted in problems with the identification of certain relationships. Namely, it is necessary to develop an analytical strategy that would enable the measuring of that part of production time that brings direct utility (turns into leisure):

$$L_i = l_i + g(H_i) \quad (1)$$

where:

L_i – total time of direct utility,

l_i – time remaining after deducting market and household work from its total amount,

H_i – time devoted to household work,

[1] Henceforth, the Graham and Green model will be referred to as G-G.

$g(H_i)$ – function describing the scale of joint production (the part of household work time which turns into leisure), which satisfied:

$0 \leq g(H) \leq 1$
$g''(H) < 0$
$\lim_{H \to 0} g(H) = 1$
$\lim_{H \to T} g(H) = 0$

Apart from assumption (1), the G-G model also assumes the following relationships:

$$U = u(C, M_h L_h, M_w L_w) \quad (2)$$

where:
C– goods that provide direct utility,
$M_i L_i$ – effective leisure of husband and wife,

M_w and M_h represent the measures of the productivity of wife and husband respectively. Individuals are compensated in the market according to their level of productivity, so we could rewrite the hourly wages as $W_i = r\, M_i$ $(i = w, h)$ where r is the rate of return to human capital. Thus $M_i L_i$ is effective leisure. When time is used in home production, it may be either more or less productive compared to market activity depending upon whether human capital skills are market-oriented or home-oriented. To capture this notion the effective home production is written as $M_i^a H_i$.

Goods can be obtained in the market or produced at home:

$$C = X_m + Z \quad (3)$$

where:
X_m – goods purchased in the market,
Z – goods produced in the household,
Household production obeys the technological relationship:

$$Z = z(X_z, M_h^a H_h, M_w^b H_w) \quad (4)$$

where:
X_z – market purchased inputs for production purposes,
$M_h^a H_h$ – effective time inputs of husband
$M_w^b H_w$ – effective time inputs of wife.
Then:

$$X_m + X_z = W_h N_h + W_w N_w + \vartheta \quad (5)$$

where:
W_i – hourly market wages,
N_i – hours of work,
ϑ – non-labour income,
and time of a day is divided according to the formula:

$$l_i + H_i + N_i = T \quad (6)$$

where:
l_i – time devoted neither to work in the market nor work at home, $i = h, w$,
T – total time.

These relationships are the utility function (2) which is maximized; the goods that provide direct utility for members of the household (3); the production function (4); the budget constraint (5); and the time constraint (6) where relationships (3)-(7) are accepted conditions (Graham & Green, 1984).

In their work Graham and Green wrote the equation (4) in Cobb-Douglas form, estimating the value of home production for a series of various assumptions assigned to the following parameters:

$$Z = A(M_h^a H_h)^{\gamma_h}(M_w^b H_w)^{\gamma_w} X_z^{\beta} \quad (7)$$

where:

A – variable represents general scale parameter which construction is described further in the article,

M_i – measure of the productivity (or human capital) of the man and woman, i = *h (husband), w (wife),*

H – domestic production time,

$\gamma_h, \gamma_w, \beta$ – returns-to-scale parameters,

a, b – the positive parameters can be less than, equal to, or greater than 1.0 depending upon whether the individual is less productive, equally productive, or more productive at home than in market work,

X_z – average daily expenditure of household on consumption goods.

(Graham & Green, 1984) performed calculations on a sample of 921 married couples, in which both partners worked. In none of the nine variants of the model tested by the authors did the absolute value of the parameters γ_h, γ_w exceed the value of β. This means that the elasticity of production in relation to market goods was higher than in relation to the spouses' working time. In the results presented, home production was not characterized by increasing returns to scale. For both partners, the productivity of market work exceeded the analogous parameter describing household production.

An attempt to relax the restrictions with regard to joint production in the HPF model was also undertaken by Kerkhofs and Kooreman (2003). The authors used a form of the production function describing the transformation of working time into consumption time, which was proposed by Graham and Green. Abandoning arbitrary assumptions with regard to the value of market goods, they used the so-called net production function, in which only the time spent on work was taken into account. The main justification for such a strategy is the above-mentioned lack of detailed data relating to market goods used in household production.

The quadratic function used in the study also made it possible to determine the relationship between the spouses' working time expenditures in the production process (Kerkhofs & Kooreman, 2003). The influence of selected socio-economic characteristics of both households and individuals was taken into account in the estimations. The results of the calculations suggest that the spouses' work expenditures in the course of performing household duties are substitutive in nature. Thus, an increased supply of market work by the wife, which will occur at the expense of her home production time, should therefore trigger her husband's greater production activity in the non-market sphere.

Examples of applying the methodology developed by Kooreman and Kerkhofs can be found in the works of Pylkkänen (2002) and Gørtz (2006, 2011). The latter introduced a modification to this procedure in the form of an alternative estimator of production function parameters.

One of the most significant publications on the production and consumption of households is the work by Gronau and Hamermesh (2003). The authors undertook to examine the ways of combining market goods and specific categories of time in households, which essentially had not been done before. Apart from a few exceptions in which only some selected forms of activity were considered, no prior empirical research had been undertaken to describe the production technology as well the inputs of time and goods involved in the production processes in the non-market sphere.

2. Data and methodology

Similarly to some studies devoted to non-market production, the calculations performed in this study take into account only those families in which both partners filled in the activity diaries on the same day (Kooreman & Kapteyn, 1987). Moreover, the sample was limited to households where the husband and wife (or partners in an informal relationship) are the only adults and their age is between 18-59 years. This was dictated by two assumptions. Firstly, the aim is to estimate the parameters of the production function in conditions when the analysed individuals cannot count on the help of other adults with household chores. In this way, the production technology can be described more precisely, and it is possible to observe the relationship between the spouses in the resource management process. Secondly, the authors wanted to focus on people of working age, for whom the natural alternative to home production is undertaking market work. Consequently, the working age range for women that was adopted is five years shorter than that for men.

Model 1 includes only households in which both adults declare performing paid work. In model 1a this assumption was relaxed in relation to the woman, which means that she is not required to be in paid employment (but man has to work). In model 1b, this assumption was relaxed in relation to the man but not in relation to women. In each household, number 1 represents the woman, and number 2 the man (the few same-sex relationships described in the TUS database did not meet the inclusion criteria for the research sample).

Table 1 shows the mean values of the socio-economic variables in six groups of households. The groups were created in such a way as to be able to compare childless households and those where the couples had children. Unfortunately, direct estimation of model parameters for childless families causes numerical problems resulting from the collinearity of a considerable number of the variables. Therefore, indirect comparisons were made, comparing the sample of families meeting the conditions of models 1, 1a and 1b with a sub-sample of families in which an additional condition assumed the presence of at least one child.

Only information from those diaries that were filled in "on a normal working day" (and in the case of unemployed people "on an ordinary day") was used for estimating the average values describing the people in each household. The reason for this was to record and describe non-market activity in the most usual conditions, disregarding the ways of spending time during days off, sick leave, holidays etc.

The TUS database contains incomplete information on the earnings of people who completed the diaries because some respondents did not provide such data. For those who provided full information, hourly rates were estimated taking into account the declared average number of hours that the respondents usually work. However, the vast majority of the TUS participants answered the question about their learned or actual occupation. Thus, when preparing statistical material, the contents of two different databases were combined. In addition to information about time use, data referring to the average hourly wage rates from the Polish Central Statistical Office (GUS) survey of remuneration structure by occupation (Z-12 GUS report) was also used. The latter database contains information on hourly rates in October 2013. For people who filled in the time-use diaries in other months, the appropriate rates were adjusted for inflation using the consumer price index. The final calculations were based on these amounts adjusted to hourly net pay rates. Thus, an assumption was made that when deciding on the allocation of their time, household members take into account the hourly net pay rate rather than the gross rate. In the procedure of determining the dual price of time, rates based on occupation were used only for those people who refused to reveal their actual earnings.

Table 1. Descriptive statistics

Socio-economic variables	Model 1		Model 1a		Model 1b	
	With or without Children	With Children	With or without Children	With Children	With or without Children	With Children
HW_w	277.11	317.23	291.92	334.66	277.21	315.99
HW_h	166.59	185.44	168.53	185.78	171.24	191.98
KID0- 2 (A1)	0.201	0.315	0.210	0.320	0.202	0.312
KID3- 6 (A2)	0.283	0.443	0.294	0.447	0.284	0.440
KID7- 12 (A3)	0.370	0.579	0.397	0.603	0.376	0.582
KID13-18 (A4)	0.342	0.536	0.343	0.520	0.351	0.542
Family size (A5)	3.006	3.576	3.050	3.595	3.019	3.576
% of HH with dishwasher (A6)	57.33 %	52.22 %	57.64 %	53.65 %	57.48 %	52.63 %
% of HH with car (A7)	9.89 %	8.74 %	9.99 %	9.04 %	10.16 %	9.19 %
W_w	15.13	15.59	14.23	14.15	15.11	15.54
W_h	16.15	16.01	16.36	16.06	15.81	15.48
$EDUCA_w$	14.83	15.00	14.80	14.89	14.78	14.93
$EDUCA_h$	13.62	13.69	13.64	13.66	13.59	13.64
AGE_w	37.79	35.59	37.38	35.31	37.73	35.57
N	2 993	1 991	3 763	2 477	3 062	1 980

HW – household work time
KID – children age
W – market wage in Polish zlotys
EDUCA – years of education
AGE – spouses' age in years

Source: Own calculations based on TUS 2013 data.

When comparing the populations selected for the research (Table 1), it can be seen that, on average, women spend more time working at home than men. What is more, in each of the models the time devoted to work at home in households where there are children is definitely longer. Based on information relating to the sample of households in which there was at least one child and the sample where this condition did not apply, it is possible to estimate the approximate average time devoted to household work in households without children. For example, in models 1, 1a and 1b it was respectively 197, 209 and 206 minutes for women and 129, 135 and 133 minutes for men.[2]

The time devoted to work at home increases when one person in the household is unemployed (which can be assessed by comparing the working time in model 1 with that in models 1a and 1b). As expected, the average time devoted to household work changes to a greater extent for those people to whom the condition of having a job does not apply: in model 1a women work longer, and in model 1b men spend more time on work. This applies to households both with and without children.

The percentage of households owning a car is surprisingly low. A significant number of households use a company car or a vehicle registered to a private firm. This is connected with the Polish legal regulations on business operations and is aimed at tax optimization. The respondents most probably did not declare such a vehicle as their own. Moreover, it can be

[2] The first of these values was calculated as follows: total number of women's working minutes in the sample of households with or without children (2 993*277.11 = 829390.23); total number of women's working minutes in relation to the sample of families with children (1 991*317.23 = 631604.93); difference in total working time divided by the number of people of a given gender in households without children (197785.3/1002=197.39).

seen that household equipment, assessed on the basis of having a dishwasher and a car, is better in families without children.

In the analysed households, women usually have a better education (expressed in the number of years of education), but they receive a lower average salary. Women who have children and who decide to enter the labour market usually do better-paid work. In the case of men, the opposite is true: men from households where there are no children have higher earnings. In addition, on average, the women without children included in the study are older than those who are mothers.

The calculation methodology used in the analysis is based predominantly on the procedure described in the previously mentioned paper by Graham and Green (1984). However, it has been modified to some extent due to the information content of the databases available in Poland. Among the characteristics describing the sample, Graham and Green included information on the number of rooms available to families as well as whether they are owners-occupiers. Such information was not collected in Polish time-use surveys. Thus, having a dishwasher and a car was included among the factors affecting the amount of household work.[3] According to Bridgman (2013), home production has always been capital-intensive, which is connected with, among other things, the significant importance of housing capital. According to his calculations, with the growing availability of increasingly better household appliances, the share of human capital in relation to real capital has actually diminished over the years.

In the production function (7), the *M* coefficients are a combination of age and level of education, and the exponents *a* and *b* indicate whether the human capital of a given person is more oriented to market or home production (i.e. in which area the individual is more efficient).

The direct satisfaction during home production that appeared in equation (1) is measured according to the following formula:

$$g_i(H_i) = H_i\left[1 - \frac{1}{1+\delta_i}\left(\frac{H_i}{T}\right)^{\delta_i}\right], i = h, w \tag{8}$$

where:

g_i – function describing the part of working time that changes into leisure time,

T – total time for an individual,

δ_i – parameters describing the scale of joint production for each spouse,

h – husband,

w – wife.

The *g(H)* function satisfy conditions i) – iv) from formula (1) and has several properties. The initial units of time that are inputs in production can bring direct pleasure, but as the household work continues, it turns into an unpleasant obligation (Graham and Green, 1984). The proposed structure makes it possible to take into account not only intermediate states but also extreme situations; such as a total lack of joint production, or perceiving the entire production time as leisure.

Based on previously adopted assumptions, the first order optimization conditions can be written in the following form:

$$\beta A(M_h^a H_h)^{\gamma_h}(M_w^b H_w)^{\gamma_w} X_z^{\beta-1} = 1 \tag{9}$$

$$\gamma_h A \mathrm{M_h}^{a\gamma_h} \mathrm{H_h}^{\gamma_h - 1}(M_w^b H_w)^{\gamma_w} X_z^{\beta} = W_h\left(\frac{H_h}{T}\right)^{\delta_h} \tag{10}$$

[3] In the original proposal, instead of this information there was information about the ownership of the house or apartment occupied and the number of rooms.

$$\gamma_k A(M_h^a H)^{\gamma_h} \mathrm{M_w^{b\gamma_w}} \mathrm{H_w^{\gamma_w - 1}} X_z^{\beta} = W_w \left(\frac{H_w}{T}\right)^{\delta_w} \quad (11)$$

Simultaneous solutions of (9), (10) and (11) with respect to H_k and conversion into a log-linear form result in the following:

$$lnH_w = c' + \frac{1}{q} lnA + \frac{\frac{\gamma_h}{1+\delta_h} + \beta - 1}{q} lnW_w - \frac{\frac{\gamma_h}{1+\delta_h}}{q} lnW_h + \frac{b\gamma_w}{q} lnM_w + \frac{a\gamma_h}{q} lnM_h \quad (12)$$

In notation (12) c' is a constant, while q:

$$q = (1-\beta)(1+\delta_w) - \gamma_w - \frac{\gamma_h(1+\delta_w)}{1+\delta_h} \quad (13)$$

Taking into account microeconomic cross-sectional data, relationship (12) can be estimated according to formula (14). In the adopted procedure, estimation of the parameters of this linear function precedes the determination of the final form of the Cobb-Douglas function.

$$lnH_w = c + klnA + llnW_w + mlnW_h + nlnM_w + olnM_h \quad (14)$$

where:
W_i – hourly pay rates of the man and the woman.

In equation (14) *c* is a constant, while the remaining parameters (*k, l, n, o* and *p*) are used to estimate the appropriate parameters of the production function and the form of the *g(H)* relationship, which describes the scale of direct utility. Solving (12)-(14) we obtain:

$$a\gamma_h = \frac{o}{k} \quad (15)$$

$$b\gamma_w = \frac{n}{k} \quad (16)$$

$$\frac{\gamma_h}{1+\delta_h} = \frac{-m}{k} \quad (17)$$

$$\beta = \frac{k+l+m}{k} \quad (18)$$

$$b = \frac{-n}{1+l(1+\delta_w)} \quad (19)$$

This system is underidentified by two. To estimate all seven parameters we need two additional equations, which are obtained by examining special cases of the problem. Appendix 1A presents various combinations of the parameters which were obtained in special cases, based upon equations (15)-(19), and which may be the results of a solution that takes into account first order equilibrium conditions with respect to the woman's working time. (Graham & Green, 1984). When estimating the parameters of the production function, the authors did not make an *a priori* assumption about the range in which the total value of the $\gamma_h + \gamma_w + \beta$ exponents should be. Thus, they did not prejudge the nature of returns to scale in the non-market sphere. The results of estimation (14) are presented in Table 2. Graham and Green do not indicate which of the adopted variants is the best, hence it can be assumed that their aim was to compare the results of production activity for different types of families (Allen, 2015).

3. Results of estimations

In all models, the dependent variable was the woman's household work time (person 1). According to the form of equation (14), the values of the variables were logged. Like in the paper by Graham and Green, general scale parameter *A* is a combination of variables relating to the number of children of various ages, the size of the family, household equipment facilitating housework (dishwasher), and car ownership . In their paper Graham and Green calculate a proxy for *A* according to the formula:

$$A = \prod_{i=1}^{7} A_i^{\alpha_i} \quad \text{with} \quad \sum_{i=1}^{7} \alpha_i = 1 \tag{20}$$

where A_i represent variables indicating the presence of children, size of the family and household equipment. After calculating the parameters of the regression function for variables A_i separately (together with the other variables from equation (14)), the value of scaling factor *A* was calculated for each household and on this basis the parameters of equation (14) were re-estimated.

Human capital is a combination of education and age in the case of women, or is represented by education in the case of men. The procedure of calculation the human capital value was the same as for the general scale parameter. Parameter values obtained as a result of equation (14) estimations are presented in Table 2.

Table 2. Estimated parameters of equation (14); dependent variable: logarithm of woman's household time

	Model 1		Model 1a		Model 1b	
	With or without Children	With Children	With or without Children	With Children	With or without Children	With Children
A	1.25 (0.04)*	0.99 (0.05)*	1.24 (0.04)*	0.98 (0.05)*	1.09 (0.03)*	0.85 (0.04)*
W_w	-0.006 (0.02)	-0.03 (0.03)	-0.005 (0.02)	-0.02 (0.03)	-0.13 (0.01)*	-0.16 (0.01)*
W_h	0.014 (0.02)	0.013 (0.02)	0.005 (0.016)	0.015 (0.016)	0.017 (0.017)	0.04 (0.02)*
M_w	0.41 (0.05)*	0.26 (0.09)*	0.4 (0.05)*	0.23 (0.08)*	0.45 (0.05)*	0.3 (0.08)*
M_h	-0.15 (0.04)*	-0.15 (0.05)*	-0.15 (0.04)*	-0.15 (0.05)*	-0.17 (0.04)*	-0.17 (0.05)*
Constant	3.81 (0.22)*	5.25 (0.24)*	3.85 (0.22)*	5.32 (0.21)*	3.83 (0.2)*	5.23 (0.21)*
N	2 993	1 991	3 062	1 980	3 763	2 477
R^2	0.23	0.19	0.23	0.19	0.27	0.24
F	179.8	88.5	183.1	92.4	279.4	154.2

A – productivity parameter
W – hourly wage rates
M – productivity (or human capital)

Source: Own calculations based on Polish TUS 2013.

It can be seen that an increase in general scale parameter *A* extends the woman's household work time. This occurs in all the equations presented in Table 2, but the change is greater for childless families, which may result mainly from the fact that the household is equipped with a dishwasher or car (the other *A* variables are constant). This can be explained

by the specific behaviour of childless families: if women spend more time on household work, they are more likely to purchase appliances that facilitate such work (a dishwasher was not part of standard household equipment in 2013). In turn, car ownership is generally common among families that live further away from the city centre, which are usually larger and require more household work.

The lesser change in household work time with an increase in general scale parameter *A* for families with children results, at least in part, from the equivocal impact of the presence of children of different ages on the time devoted to performing household duties. Younger children require more care, and therefore more work. Older ones, on the other hand, do not need so much attention from their parents and can even do some household chores, thus helping their parents. This is confirmed by negative parameter values for the variables describing the influence of the presence of children from the oldest age group on the woman's working time (results of estimation not presented in this article).

Just as it was found in other studies, (Gronau, 1977; Graham & Green, 1984) women with higher earnings on average spend less time on housework (negative parameter values for the W_w variable). This is one of the predictions of the HPF model, according to which an increase in the price of a given person's time results in a reduction of their involvement in home production. The estimations shown in Table 2 also show that an increase in the man's earnings increases the woman's household work time, which is confirmed by positive parameter values for the W_h variable. Unfortunately, in most cases this interpretation is biased because the parameter values were not statistically different from zero (at a significance level of 5%).

An increase in the human capital of women results in an extension of their housework time. The behaviours responsible for this increase are very similar in the case of men, where a rise in human capital causes a reduction in women's household work time (which can be explained by their partner's greater participation in household duties). The change in women's household work time when their human capital increases is always two to three times greater than the change in an identical situation in the case of men.

Table 3 lists the parameters of the production function calculated for individual variants of the assumptions concerning the production process. Comparing them makes it possible to assess the differences in production technology between households in which both people do market work and families where one of the partners may be unemployed. The table shows only the parameters of those models whose construction included an additional assumption about the presence of children in the household.

Parameters γ_w and γ_h reflect the impact of the spouses' working time on the value of home production. Their total together with the value of parameter β provides information about the returns to scale that are achieved in the production process. In all Case 3 variants, this sum ($\gamma_w+\gamma_h+\beta$) is equal to 1 because constant returns to scale are assumed here. Cases 2 and 4 indicate increasing returns to scale of the production activity, while in Case 1 the sum of the values of these parameters is less than one, which indicates decreasing returns to scale.

In most cases, the values of parameter γ_w (wife) are negative, whereas the values of γ_h (husband) are usually positive. At the same time, in absolute terms, the values are generally relatively low. The exceptions are estimations for Cases 3B, 3F and 4, i.e. instances for which no jointness was assumed for men or the same jointness was assumed for both partners. It is worth mentioning that negative values of parameter γ mean that a reduction in the time input would bring a higher production value. However, if a person decides to work in such a situation, one can presume that the performed activities are for them a source of direct utility.

Table 3. Production function parameters for specific cases

	Case 1	Case 2	Case 3A	Case 3B	Case 3C	Case 3D	Case 3E	Case 3F	Case 4
Model 1 with children									
γh	-0.014	-0.149	-0.014	0.991	-0.149	-0.242	-0.020	-0.927	-2.720
γw	-0.024	0.257	0.029	-0.976	0.164	0.257	0.035	0.942	4.707
β	0.985	0.985	0.985	0.985	0.985	0.985	0.985	0.985	0.985
a	10.934	1.000	10.935	-0.150	1.000	0.151	7.263	0.160	0.055
b	-0.264	1.000	9.011	-0.264	1.572	1.000	7.263	0.273	0.055
Model 1a with children									
γh	-0.046	-0.195	-0.046	1.131	-0.195	-0.212	-0.176	-0.420	-0.507
γw	-0.013	0.358	0.192	-0.985	0.341	0.358	0.321	0.566	0.928
β	0.854	0.854	0.854	0.854	0.854	0.854	0.854	0.854	0.854
a	4.226	1.000	4.226	-0.173	1.000	0.229	1.113	0.465	0.385
b	-0.363	1.000	1.863	-0.363	1.048	1.000	1.113	0.632	0.385
Model 1b with children									
γh	-0.015	-0.152	-0.015	1.000	-0.153	-0.223	-0.016	-1.879	-35.009
γw	-0.008	0.231	0.023	-0.992	0.161	0.231	0.024	1.887	53.060
β	0.992	0.992	0.992	0.992	0.992	0.992	0.992	0.992	0.992
a	10.056	1.000	10.056	-0.153	1.000	0.154	9.520	0.081	0.004
b	-0.233	1.000	9.867	-0.233	1.438	1.000	9.520	0.122	0.004

Source: Own calculations based on GUS data.

Parameter β is only slightly lower than 1, which with constant returns to scale (Cases 3A-3F) and with low levels of γ_1 and γ_2 means that the value of home production is mainly determined by the input of market goods. The least significant role of market goods in determining the value of home production occurs in model 1a, i.e. in households where the woman could be unemployed.

The value of parameter *a*, referring to the man's efficiency in home production in relation to market production, is less than 1 for variants 3B, 3D, 3F and 4. Considering that Cases 2 and 3C assume neutrality in the man's home and market productivity (a=1), this means that male partners are typically more productive on the market than at home.

As regards women, the value of parameter *b* is also usually lower than 1. Market productivity does not exceed home productivity in the case of the following assumptions: no jointness for the husband (3A), neutrality of the man's home and market productivity (3C), and equal relative work efficiency at home and in the market for both partners (3E).

In order to assess the output of home production, it was also necessary to include information about the monetary value of the market goods used in this process as inputs (X_z). For this purpose average expenditure on consumer goods was used, based on data from the 2013 GUS household budget survey. Groups of households with characteristics corresponding to those from the TUS survey were selected for the calculations, and the parameters of models 1, 1a and 1b were estimated for those households. This made it possible to assign the value of monetary expenditure to individual households (Allen, 2015). Table 4 presents the values of home production averaged out for the aforementioned samples and the adopted variants of the production process.

Table 4. Monetary value of home production outputs in Polish zlotys[4]

Case 1	Case 2	Case 3A	Case 3B	Case 3C	Case 3D	Case 3E	Case 3F	Case 4
Model 1 with or without children								
529.8 (120.4)	15515.8 (4985.6)	4786.1 (955.9)	3778.1 (3827.8)	5226.8 (1249.8)	7564.5 (3071.6)	4847.9 (975.3)	3800.4 (2266.6)	362.7 (279.7)
Model 1a with or without children								
458.6 (110.5)	23620.5 (9440.6)	8719.6 (2403.6)	6399.7 (6651.5)	9685.3 (3193.5)	14485.3 (6659.9)	9001.7 (2581.9)	9675.2 (3182.8)	1079.5 (478.3)
Model 1b with or without children								
518.0 (120.6)	14306.1 (4700.6)	4501.7 (935.6)	3588.7 (3631.0)	4908.8 (1233.7)	7149.2 (2984.1)	4528.7 (945.3)	3756.2 (1586.4)	562.2 (313.1)
Model 1 with children								
578.3 (141.4)	3205.3 (1075.1)	1693.6 (432.1)	1250.1 (1622.2)	1871.8 (562.8)	2707.0 (991.8)	1701.6 (435.7)	4956.2 (8937.6)	3.00e+11 (3.37e+12)
Model 1a with children								
366.2 (105.2)	4416.9 (1808.5)	3540.5 (1212.6)	2371.9 (3263.1)	4013.2 (1618.6)	5959.3 (2476.7)	3942.3 (1544.3)	5045.6 (3109.5)	28436.3 (24294.0)
Model 1b with children								
632.1 (163.7)	2507.7 (857.6)	1516.5 (405.4)	1151.8 (1515.1)	1674.7 (530.9)	2407.9 (880.4)	1517.4 (405.8)	58004.0 (435856.2)	8.48e+36 (2.89e+37)

Source: Own calculations based on GUS data.

Comparing model 1 with models 1a and 1b, it can be seen that in a situation where the woman could be unemployed (1a), the value of home production is usually higher. The opposite is true when the man could be unemployed; relaxing the assumption of the husband being in employment usually leads to a drop in the value of home production. This is directly related to earlier observations on the parameters of the production function (relationship of γ_w and γ_h to β, and the a and b values) and differences in the hourly rates for men and women. The significant role of market goods in determining the value of production and, hence, the role of household members' earnings is of decisive importance here. If the unemployment of the partner who on average earns more is allowed, then consumer spending on the most important inputs in the production process falls more than in the case of the woman being unemployed.

Comparing the value of home production within the same model but between households where there are children and those where there may not be any children, this value is usually higher in the latter case. The only exceptions are variants 1 and 4. It should be noted, however, that in Case 4 (for families with children) the estimation of the value of household work is generally not very reliable.

Conclusion

Among the findings that are presented in this paper, three seem to be the most interesting. Firstly, the values of parameters a and b are usually lower than one, which means that both women and men are characterized by higher productivity in market conditions compared to home production. This does not come as a surprise, given that in market conditions there is a completely different organization of work, supervision, reward system etc. Similar results were obtained by Graham and Green (1984) and Allen (2015). The results of the present study are similar to the findings published in the aforementioned articles also in the respect that market goods as inputs in the production process have been found to play a

[4] An average exchange rate in 2013 was 1 euro = 4.20 zlotys.

greater role in determining its value than the time spent by spouses. Thus, in the vast majority of cases, the elasticity of production relative to market goods is clearly greater than its elasticity in terms of time expenditure. This is indicated by the estimations of parameters γ_w, γ_h and β. Therefore, it can be restated after Allen (2015) that if material inputs in household production are a function of their earnings, the latter will be one of the most important factors differentiating the value of the non-market production outputs of individuals.

In this context, the values of market production in families without children being higher than in households where children are present seem to be credible and in line with expectations. In the latter, a significant part of household work consists of childcare (which was included in home production), which belongs to the time-intensive category (Stafford & Jean Yeung, 2005). Especially in the case of the youngest children, production occurs with a considerable relative time expenditure of the household members. Additionally, in households with small children, the woman remains outside the labour market more often than in the case of childless couples. This means a lower family income and, consequently, a reduction in the most important production input from the point of view of determining the value of the output of this activity.

Our result and its interpretation seems more credible than the findings presented in Allen's work (2015). In his study, in both types of families (with and without children) the value of production turned out to be similar. The author interprets this by suggesting that childless families simply prepare for having children and therefore apply a similar production technology to those who already have children.

The Graham and Green methodology (1984) used in the present analysis has certain shortcomings. One of them is assessing the statistical significance of production function parameters (Table 3), which is problematic to the point of being entirely impossible. The estimations are performed only indirectly, through operations on linear regression function parameters (14). In view of the fact that a household production function is often not observable, i.e. its functional form cannot be tested econometrically, the presented results should be interpreted with great caution (Ebert, 2007).

The parameter values obtained during the calculations and the signs against them, however, are consistent with the predictions of the HPF model. It turns out that the higher the cost of women's time, the lower their inclination to get involved in household work (parameter for variable W_w, Table 2) (cf: Kooreman & Kapteyn, 1987). In turn, an increase in the man's hourly rate results in a greater involvement of the woman in home production. In addition, the presence of the youngest children increases the inputs in non-market production to the greatest extent; but as they grow up, they require less and less direct care (cf. Gronau, 1976).

Pollak and Wachter (1975) argued that people do not always spend their time exclusively on one activity at a time. The assumption of the lack of direct utility in the production process, which was adopted by Becker (1965) and maintained, among others, by Gronau (1977), faced justifiable criticism. The existence of jointness seems to be supported not only by sheer intuition, but also by the results of the calculations presented in this study as well as those obtained by, among others, Graham and Green (1984) and Allen (2015). As rightly pointed out by Kerkhofs and Kooreman (2000), when the phenomenon of joint production is taken into account in a model, the actual phenomena related to non-market production can be described more accurately.

Summing up, it is worth noting that in the presented analysis it was possible to disaggregate time use, which could not be done with the consumption of market goods due to the lack of relevant data. Kooreman and Kapteyn (1987) point out that on the basis of Hicks's composite commodity theorem it can be assumed that in such a situation the aggregation of consumption does not cause any loss of information regarding the determinants of time use.

Nevertheless, subsequent research on production technology should strive to better describe the consumption structure in order to more accurately account for the inputs of market goods in the process of home production.

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Appendix

Table 1A. Estimations of the parameters of the household production function and joint production according to the adopted assumptions

Case	γ_m	γ_k	β	a	b	δ_m	δ_k
1	$\frac{-m}{k}$	$\frac{1+l}{-k}$	$\frac{k+l+m}{k}$	$\frac{-o}{m}$	$\frac{-n}{1+l}$	0	0
2	$\frac{o}{k}$	$\frac{n}{k}$	$\frac{k+l+m}{k}$	1	1	$\frac{o+m}{-m}$	$\frac{1+n+l}{-l}$
3A	$\frac{-m}{k}$	$\frac{-l}{k}$	$\frac{k+l+m}{k}$	$\frac{-o}{m}$	$\frac{-n}{l}$	0	$\frac{-1}{l}$
3B	$\frac{1-m}{k}$	$\frac{1+l}{-k}$	$\frac{k+l+m}{k}$	$\frac{o}{1-m}$	$\frac{-n}{1+l}$	$\frac{-1}{m}$	0
3C	$\frac{o}{k}$	$\frac{l+m+o}{-k}$	$\frac{k+l+m}{k}$	1	$\frac{-n}{l+m+o}$	$\frac{o+m}{-m}$	$\frac{m+o-1}{l}$
3D	$\frac{l+m+n}{-k}$	$\frac{n}{k}$	$\frac{k+l+m}{k}$	$\frac{-o}{k+l+m}$	1	$\frac{l+n}{m}$	$\frac{1+n+l}{-l}$
3E	$\frac{-o(l+m)}{k(o+n)}$	$\frac{-n(l+m)}{k(o+n)}$	$\frac{k+l+m}{k}$	$\frac{-(o+n)}{l+m}$	$\frac{-(o+n)}{l+m}$	$\frac{ol-nm}{m(o+n)}$	$\frac{n(m-1)-o(l+1}{l(o+n)}$
3F	$\frac{m(1-l-m)}{k(m+l)}$	$\frac{m+l(m+l)}{-k(m+l)}$	$\frac{k+l+m}{k}$	$\frac{o(m+l)}{m(1-l-m)}$	$\frac{-n(m=l)}{m+l(m+l)}$	$\frac{-1}{m+l}$	$\frac{-1}{m+l}$
4	$\frac{mo}{k(ol-nm)}$	$\frac{ol-nm}{k}$ $\frac{}{nm}$	$\frac{k+l+m}{k}$	$\frac{ol-nm}{m}$	$\frac{ol-nm}{m}$	$\frac{o(l+1-nm)}{nm-ol}$	$\frac{o(l+1-nm)}{nm-ol}$

Key:
Case 1 – no joint production
Case 2 – neutrality of human capital (no difference in the productivity of market and household work)
Case 3 – constant returns to scale
Case 3A – no joint production for the man
Case 3B – no joint production for the woman
Case 3C – neutrality of the man's human capital
Case 3D – neutrality of the woman's human capital
Case 3E – identical relative marginal productivity (at home and in the market) of men and women
Case 3F – identical scale of joint production
Case 4 – simultaneous fulfilment of conditions 3E and 3F.

Source: Graham and Green, 1984