Adult Equivalent Scales Once More—
A Developmental Approach

John R. Tedford, Oral Capps, Jr., and Joseph Havlicek, Jr.

Descriptions of adult equivalent scale models typically do not explain why or provide the explicit rationale underlying their selected age classes and life cycle components. A model is presented where the life cycle is comprised of a sequence of developmental and transitional phases. A comparison of adult scale parameter estimates for total food expenditure from this model is made with estimates from the Blokland and Buse-Salathe models. The findings suggest that the Blokland model is too restrictive to portray consumer behavior over the life cycle. Empirical results based on the proposed model are similar to those based on the Buse-Salathe model.

Key words: demand analysis, equivalent scales

A number of approaches have been used to introduce household size and composition into specifications of Engel functions. In particular, economists have been concerned with the generation of adult equivalent scales to reflect the consumption behavior and/or requirements of household members in different age-sex classifications. Adult equivalent scales, alternatives to per capita measures, provide information on the contribution of various household members to the consumption behavior of the household. The common practice is to assign the adult male a weight of one and to assign other household members fractional weights based on their relative consumption needs. The weights can be based on physiological and nutritional requirements (Engel, Stone, Hymans and Shapiro) or on observed consumer behavior (Sydenstricker and King, Prais and Houthakker, Barten, Price, Singh and Nagar, Blokland, Buse and Salathe, and Muellbauer 1980). The Barten and Muellbauer scales are structural parameters useful in welfare analysis (primarily the evaluation of the cost of living due to changes in household composition), while the Sydenstricker-King, Prais-Houthakker, Blokland, and Buse-Salathe scales are reduced-form parameters useful in forecasting (e.g., the effect of changes in household composition on household expenditures). Household equivalent scales, aggregates of the adult equivalent scales, are consequently weighted household size measures, with adjustments for differences in age-sex composition.

The common approach in the construction of equivalent scales is to group household members into various age-sex categories so that the specific scales are stepwise discrete (Sydenstricker and King, Prais and Houthakker, Price). However, alternative adult equivalent scale designs draw upon Friedman as well as Blokland and Somermeyer in specifying the scales as continuous functions of age and sex of the household members (Blokland, Buse and Salathe). This latter approach overcomes the restrictiveness of the former approach. Changes in household expenditure patterns are then explicitly functions of the biological and psychological growth (continuous processes) of individual household members.

Despite the generality of the continuous equivalent scale specifications over the stepwise-discrete specifications, two major limitations of equivalent scale models remain. First, the rationale underlying selected age classes and life cycle specifications is seldom explicat...
ity stated. No explanations are typically given for the selection of the boundary values of the age classes, and no explanations are usually given why consumer behavior should be different at various stages of the life cycle. Second, sociodemographic factors, generally key determinants of household expenditure, are often excluded in equivalent scale models.

This paper attempts to resolve these shortcomings. In short, an adult equivalent scale model is formulated based upon concepts from the fields of psychology as well as child and human development. A number of informational sources have been used to produce equivalent scales, but none appear to have been based upon concepts from these fields (Blokland, Muellbauer 1974). The primary objective is to generate an equivalent scale (called the TCH scale) which the conception and components of the life cycle are based explicitly upon the research by Levinson et al. and upon concepts from child and human development described by Duvall and by Vander Zanden. A secondary objective is to present a comparison, both theoretical and empirical, of alternative continuous equivalent scale specifications, namely the TCH, Blokland, and Buse-Salathe models. The uniqueness of this research is the linkage from key concepts in psychology, child development, and human development to economic concepts concerning adult equivalent scales. This linkage helps to explain why individual household members of various age-sex compositions make different contributions to household consumption behavior.

The Life Cycle Concept

Based primarily on the research findings of Levinson et al., the life cycle constitutes a synthesis of the step-like levels of development advocated by stage theorists in psychology with the continuous development processes advocated by learning theorists. The life cycle is viewed as a sequence of eras or, alternately, as a sequence of developmental and transitional periods. The eras, building blocks of the life cycle structure, consist of a single developmental period and one or more transitional periods. Three important characteristics are associated with this concept of the life cycle: (a) while cultural and individual variations exist, the life cycle follows a universal pattern, (b) behavior and development are different at various eras, and (c) development over the total sequence of eras is continuous.

Delineation of the boundary age values and developments associated with specific life cycle stages should yield meaningful age-class specifications and make explicit the rationale or reasons why adult equivalent scales for male and female household members might be different at various ages. Information that could be used to delineate major stages of the life cycle is presented in table 1. One could, following Levinson et al., view the life cycle either as a sequence of transitional and developmental periods or as a sequence of eras. Alternatively, one might use the ages and important events identified by Duvall, or one could use the food energy allowances for males and/or females recommended by the National Research Council. Although all the information in table 1 is used as a basis for model specification, the generation of the TCH equivalent scale in this paper is based primarily on the sequential life cycle concept which utilizes developmental and transitional periods.

The TCH Equivalent Scale

Adult equivalent scales are measures that show how much an individual household member of a given age and sex contributes to household expenditures relative to a standard household member. Following Blokland as well as Buse and Salathe, the adult scale can be denoted conceptually by \( S_j = S(a_j, s_j) \) where \( S_j \) is the scale value, \( a_j \) the age, and \( s_j \) the sex of the \( j \)th household member, respectively. As stated earlier, the TCH continuous equivalent scale consists of a sequence of transitional and developmental periods. The four developmental periods are infancy, childhood and adolescence \((0 < a_j < 17)\), early adulthood \((22 < a_j < 40)\), middle adulthood \((45 < a_j < 60)\), and late adulthood \((65 < a_j < 80)\). Each of the other five time periods are transitional periods, namely \((a_j = 0, \text{birth})\), \((17 \leq a_j \leq 22 \text{ early adult transition})\), \((40 \leq a_j \leq 45 \text{ middle adult transition})\), \((60 \leq a_j \leq 65 \text{ late adult transition})\), and \((a_j \geq 80 \text{ late late adult transition})\).

Events and activities which occur during the developmental periods shape the character of living. The following brief comments, capsulized from the work of Levinson et al., are offered to highlight some of the important at-
tributes that occur within the different developmental periods. The developmental period of infancy, childhood, and adolescence constitutes the formative phase of life. During this time span a dependent child experiences considerable biological, psychological, and social growth (Gesell, Ilg and Ames). The developmental period of early adulthood is perhaps the most dramatic of the developmental periods. It often encompasses the peak years of biological functioning and intellectual development and may be the period of greatest contradiction and stress. The developmental period of middle adulthood is characterized by several attributes. Perhaps most important is the fact that it is a period in which qualities not developed earlier can surface. Also, an individual at midlife suffers some loss of youthful vitality, and the response to this loss may alter behavioral patterns. Further, the experience of one’s mortality is of utmost importance because of the dying self of youth. Finally, the concept of “generation” is of paramount importance during these years. The character of living in the late adulthood years, the last developmental period, is altered in fundamental ways because of numerous biological, psychological, and social changes. Individuals are aware of aging and mortality and of the increasing frequency of serious illness or death. Greater emphasis is placed upon self-definition and self-satisfaction, and a primary developmental task is to find a new balance of involvement with society and with the self.

The transitional periods are times of reflection, reassessment, and planning. According to Levinson et al. these periods generally last three to six years. The transitional periods serve as boundaries to link the developmental periods, thereby providing continuity to the

Table 1. Alternative Information Sources Which Delineate Ages and Important Events of the Life Cycle

<table>
<thead>
<tr>
<th>(1) Levinson’s Transition and Developmental Periods</th>
<th>(2) Levinson’s Eras</th>
<th>(3) Duvall’s Male Profile</th>
<th>(4) NRC Food Energy Standard (FES) for Males</th>
</tr>
</thead>
<tbody>
<tr>
<td>Period</td>
<td>Age</td>
<td>Era</td>
<td>Event</td>
</tr>
<tr>
<td>Early childhood transition</td>
<td>0–3</td>
<td>Pre-adult</td>
<td>Birth</td>
</tr>
<tr>
<td>Childhood and adolescence development</td>
<td>4–16</td>
<td>0–22</td>
<td>Goes to school</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Child enters teens</td>
</tr>
<tr>
<td>Early adult transition</td>
<td>17–22</td>
<td>Early adult</td>
<td>Marries</td>
</tr>
<tr>
<td>Early adult development</td>
<td>23–39</td>
<td>17–40</td>
<td>First child is born</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>First child in school</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>First child is teenager</td>
</tr>
<tr>
<td>Middle adult transition</td>
<td>40–45</td>
<td>Middle adult</td>
<td>First child marries</td>
</tr>
<tr>
<td>Middle adult development</td>
<td>46–59</td>
<td>40–65</td>
<td>Last child marries</td>
</tr>
<tr>
<td>Late adult transition</td>
<td>60–65</td>
<td>Late adult</td>
<td>Death of one spouse in family</td>
</tr>
<tr>
<td>Late adult development</td>
<td>66–79</td>
<td>60 or more</td>
<td></td>
</tr>
<tr>
<td>Late late adult transition</td>
<td>80–death</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
changes which occur in the outgoing and in-
coming developmental phases.

Following the procedures used by Blokland
and by Buse and Salathe, cubic spline func-
tions are used to generate the TCH adult
equivalent scales as continuous functions of
age for male and female household members.
Adult scale parameters are assumed to be con-
stant, but possibly different, over the years
comprising each of the transitional periods.
The transitional periods are consistent with
the notion of interior knots or join points of
the spline functions. Levinson's early transi-
tional period of age zero to three years is
modified to correspond to age zero in the TCH
model to make the adult scales for the child-
hood years up to age seventeen similar to
those generated by Blokland and by Buse and
Salathe. This modification is consistent with
research in the field of child development
(Duvall, Vander Zanden). Finally, the NRC's
nutritional information exhibited in table 1
indicates that a male's food energy require-
ments are highest between the ages of fifteen
and twenty-two years, years which overlap Levin-
son's early adult transitional period. On this
basis, the standard household member, as-
signed a weight of one, is defined as a male
between the ages of seventeen and twenty-two
years.

The adult scale functions resulting from the
prior restrictions imposed in the TCH model
are presented in table 2. A household member
can belong to one of sixteen possible age-sex
classes. The equivalent scales for males in
various periods of the life cycle are given in
equations (1) through (9), and the equivalent
scales for females are given in equation (1) as
well as equations (10) through (17). The pa-
rameters $M1, F2, M3, F3, M4, F4, M5, and
F5$, respectively, measure the increase in the
number of adult equivalents to a household
from the addition of a newborn baby, a female
seventeen to twenty-two years of age, a male
forty to forty-five years of age, a female forty
to forty-five years of age, a male sixty to sixty-
five years of age, a female sixty to sixty-five
years of age, a male eighty years of age and
beyond, and a female eighty years of age and
beyond. On the other hand, the parameters
$E11, E21, E31, E41$ and $E12, E22, E32,$ and
$E42$ relate to the cubic functions specified for
the respective developmental periods (Blok-
land, chap. 3; Poirier).

For comparative purposes, the adult scale
functions from the Blokland as well as from
the Buse and Salathe models are exhibited in
table 3. Only four scale parameters are to be
estimated in the Blokland model, whereas six
scale parameters are to be estimated in the
Buse-Salathe model. In the TCH model six-
teen parameters are to be estimated because
of the four developmental and five transitional
periods. The TCH model is based upon con-
cepts from the fields of psychology and human
development, whereas the Blokland and Buse-
Salathe models are not. In the Blokland
model, the adult equivalent scale is repre-
sented for both males and females by a cubic
function over the childhood and adolescent
years (0 to 20). Thereafter, the equivalent
scale for males and females is, by presump-
tion, constant. The Buse-Salathe model is a
modification of the Blokland model. The
Buse-Salathe scales are not constant for all
ages beyond twenty years; the equivalent
scales in this model are constant for the ages
between twenty and fifty-five years and for
ages beyond seventy-five years.

In the Blokland model, a male household
member twenty years of age and beyond is the
standard member and hence is assigned a
weight of one. In the Buse-Salathe model, a
male household member between the ages
twenty and fifty-five is the standard member.
The parameters $eB, eBS,$ and $M1$ indicate the
relative contribution of a newborn male or fe-
male child in the Blokland, Buse-Salathe, and
TCH models, respectively. The parameters $\gamma_B$
and $\gamma_{BS}$ indicate the relative contribution a fe-
nale, either twenty years of age and beyond
(Blokland model) or twenty to fifty-five years
of age (Buse-Salathe model). In the Buse-
Salathe model, the parameters $u$ and $v$ corre-
spond to the increase in the numbers of adult
equivalents to a household due to the addition
of a male seventy-five years of age and beyond
as well as to the addition of a female seventy-
five years of age and beyond. Finally, $\delta_B, \delta_{BS},$
$\lambda_B,$ and $\lambda_{BS}$ are coefficients associated with the
cubic functions specified for male and female
household members in the childhood and ado-
lescent years.

Data and Procedures

Data for weekly time periods from the 1977–78
Nationwide Food Consumption Survey
(NFCS) are used to obtain parameter esti-
mates for the Blokland ($B$ model), Buse-
Salathe ($BS$ model) and the TCH model. Al-
though the age and sex of each household
Table 2. Adult Scale Functions in the TCH Model

<table>
<thead>
<tr>
<th>Period of Life Cycle</th>
<th>Age (a&lt;sub&gt;i&lt;/sub&gt;)</th>
<th>Sex* (s&lt;sub&gt;j&lt;/sub&gt;)</th>
<th>Adult Scale Function S&lt;sub&gt;j&lt;/sub&gt; (a&lt;sub&gt;i&lt;/sub&gt;,s&lt;sub&gt;j&lt;/sub&gt;)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males and Females</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1) at birth</td>
<td>0 or 2</td>
<td></td>
<td>M1</td>
</tr>
<tr>
<td>(2) childhood and adolescence</td>
<td>0 &lt; a&lt;sub&gt;i&lt;/sub&gt; ≤ 17</td>
<td>1</td>
<td>M1 + E11 a&lt;sub&gt;i&lt;/sub&gt; - [.11764 E11 + .01037 (M1 - 1)] a&lt;sup&gt;2&lt;/sup&gt; + [.00346 E11 + .000407 (M1 - 1)] a&lt;sup&gt;3&lt;/sup&gt;</td>
</tr>
<tr>
<td>(3) early adult transition</td>
<td>17 &lt; a&lt;sub&gt;i&lt;/sub&gt; ≤ 22</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>(4) early adulthood</td>
<td>22 &lt; a&lt;sub&gt;i&lt;/sub&gt; ≤ 40</td>
<td>1</td>
<td>1 + E21 (a&lt;sub&gt;i&lt;/sub&gt; - 22) - [.11111 E21 + .009258 (1 - M3)] (a&lt;sub&gt;i&lt;/sub&gt; - 22)&lt;sup&gt;2&lt;/sup&gt; + [.003086 E21 + .000343 (1 - M3)] (a&lt;sub&gt;i&lt;/sub&gt; - 22)&lt;sup&gt;3&lt;/sup&gt;</td>
</tr>
<tr>
<td>(5) middle adult transition</td>
<td>40 &lt; a&lt;sub&gt;i&lt;/sub&gt; ≤ 45</td>
<td>1</td>
<td>M3</td>
</tr>
<tr>
<td>(6) middle adulthood</td>
<td>45 &lt; a&lt;sub&gt;i&lt;/sub&gt; ≤ 60</td>
<td>1</td>
<td>M3 + E31 (a&lt;sub&gt;i&lt;/sub&gt; - 45) - [.13332 E31 + .01333 (M3 - M4)] (a&lt;sub&gt;i&lt;/sub&gt; - 45)&lt;sup&gt;2&lt;/sup&gt; + [.004444 E31 + .000592 (M3 - M4)] (a&lt;sub&gt;i&lt;/sub&gt; - 45)&lt;sup&gt;3&lt;/sup&gt;</td>
</tr>
<tr>
<td>(7) late adult transition</td>
<td>60 &lt; a&lt;sub&gt;i&lt;/sub&gt; ≤ 65</td>
<td>1</td>
<td>M4</td>
</tr>
<tr>
<td>(8) late adulthood</td>
<td>65 &lt; a&lt;sub&gt;i&lt;/sub&gt; ≤ 80</td>
<td>1</td>
<td>M4 + E41 (a&lt;sub&gt;i&lt;/sub&gt; - 65) - [.13332 E41 + .01333 (M4 - M5)] (a&lt;sub&gt;i&lt;/sub&gt; - 65)&lt;sup&gt;2&lt;/sup&gt; + [.004444 E41 + .000592 (M4 - M5)] (a&lt;sub&gt;i&lt;/sub&gt; - 65)&lt;sup&gt;3&lt;/sup&gt;</td>
</tr>
<tr>
<td>(9) late late adulthood</td>
<td>a&lt;sub&gt;i&lt;/sub&gt; &gt; 80</td>
<td></td>
<td>M5</td>
</tr>
<tr>
<td>Females</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(10) childhood and adolescence</td>
<td>0 &lt; a&lt;sub&gt;i&lt;/sub&gt; ≤ 17</td>
<td>2</td>
<td>F1 + E12 a&lt;sub&gt;i&lt;/sub&gt; - [.11764 E12 + .01037 (M1 - F2)] a&lt;sup&gt;2&lt;/sup&gt; + [.00346 E12 + .000407 (M1 - F2)] a&lt;sup&gt;3&lt;/sup&gt;</td>
</tr>
<tr>
<td>(11) early adult transition</td>
<td>17 &lt; a&lt;sub&gt;i&lt;/sub&gt; ≤ 22</td>
<td>2</td>
<td>F2</td>
</tr>
<tr>
<td>(12) early adulthood</td>
<td>22 &lt; a&lt;sub&gt;i&lt;/sub&gt; ≤ 40</td>
<td>2</td>
<td>F2 + E22 (a&lt;sub&gt;i&lt;/sub&gt; - 22) - [.11111 E22 + .009258 (F2 - F3)] (a&lt;sub&gt;i&lt;/sub&gt; - 22)&lt;sup&gt;2&lt;/sup&gt; + [.003086 E22 + .000343 (F2 - F3)] (a&lt;sub&gt;i&lt;/sub&gt; - 22)&lt;sup&gt;3&lt;/sup&gt;</td>
</tr>
<tr>
<td>(13) middle adult transition</td>
<td>40 &lt; a&lt;sub&gt;i&lt;/sub&gt; ≤ 45</td>
<td>2</td>
<td>F3</td>
</tr>
<tr>
<td>(14) middle adulthood</td>
<td>45 &lt; a&lt;sub&gt;i&lt;/sub&gt; ≤ 60</td>
<td>2</td>
<td>F3 + E32 (a&lt;sub&gt;i&lt;/sub&gt; - 45) - [.13332 E32 + .01333 (F3 - F4)] (a&lt;sub&gt;i&lt;/sub&gt; - 45)&lt;sup&gt;2&lt;/sup&gt; + [.004444 E32 + .000592 (F3 - F4)] (a&lt;sub&gt;i&lt;/sub&gt; - 45)&lt;sup&gt;3&lt;/sup&gt;</td>
</tr>
<tr>
<td>(15) late adult transition</td>
<td>60 &lt; a&lt;sub&gt;i&lt;/sub&gt; ≤ 65</td>
<td>2</td>
<td>F4</td>
</tr>
<tr>
<td>(16) late adulthood</td>
<td>65 &lt; a&lt;sub&gt;i&lt;/sub&gt; ≤ 80</td>
<td>2</td>
<td>F4 + E42 (a&lt;sub&gt;i&lt;/sub&gt; - 65) - [.13332 E42 + .01333 (F4 - F5)] (a&lt;sub&gt;i&lt;/sub&gt; - 65)&lt;sup&gt;2&lt;/sup&gt; + [.004444 E42 + .000592 (F4 - F5)] (a&lt;sub&gt;i&lt;/sub&gt; - 65)&lt;sup&gt;3&lt;/sup&gt;</td>
</tr>
<tr>
<td>(17) late late adulthood</td>
<td>a&lt;sub&gt;i&lt;/sub&gt; &gt; 80</td>
<td></td>
<td>F5</td>
</tr>
</tbody>
</table>

* The sex of a household member is denoted by s<sub>j</sub> = 1 if a male and s<sub>j</sub> = 2 if a female.

The variables P<sub>B</sub>, P<sub>BS</sub>, Q<sub>B</sub>, Q<sub>BS</sub>, R<sub>S</sub>, T, U, V, and VA, VB, . . . , VQ are weighted sum variables and are dependent upon the age-sex composition of the household. These variables are computed for each household from the NFCS using the expressions given in appendix tables A.1–A.3.

The equivalent scale parameters are estimated for expenditures on all foods for con-
Table 3. Adult Scale Functions in the Blokland and the Buse and Salathe Models

<table>
<thead>
<tr>
<th>Household Member</th>
<th>Age-Sex Class</th>
<th>Adult Scale Function $S_i(a_j,s_j)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blokland Model</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age ($a_j$)</td>
<td>Sex* ($s_j$)</td>
<td>$S_j(u,s)$</td>
</tr>
<tr>
<td>0</td>
<td>1 or 2</td>
<td>$e_B + \delta_B a_j - 0.18_B + 0.0075(e_B - 1)</td>
</tr>
<tr>
<td>$a_j &gt; 20$</td>
<td>1</td>
<td>$S_j(U)$</td>
</tr>
<tr>
<td>$a_j &lt; 40$</td>
<td>2</td>
<td>$e_B + \lambda_B a_j - 0.1\lambda_B + 0.0075(e_B - \gamma_B)</td>
</tr>
<tr>
<td>$a_j &gt; 40$</td>
<td>3</td>
<td>$S_j(U)$</td>
</tr>
<tr>
<td>Buse and Salathe Model</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>1 or 2</td>
<td>$e_{BS} + \delta_{BS} a_j - 0.18_{BS} + 0.0075(e_{BS} - 1)</td>
</tr>
<tr>
<td>$a_j &gt; 55$</td>
<td>1</td>
<td>$S_j(U)$</td>
</tr>
<tr>
<td>$a_j &lt; 75$</td>
<td>2</td>
<td>$e_{BS} + \lambda_{BS} a_j - 0.1\lambda_{BS} + 0.0075(e_{BS} - \gamma_{BS})</td>
</tr>
<tr>
<td>$a_j &gt; 75$</td>
<td>3</td>
<td>$S_j(U)$</td>
</tr>
</tbody>
</table>

* The sex of a household member is denoted by: $s_j = 1$ if male and $s_j = 2$ if female.

The adult equivalent scales are obtained by using the following Engel function specification:

\[
(4) \quad EXP = f(Y, EDHM, EMPHSM, SXHM, AGHM, R1, R2, R3, U1, U2, S1, S2, S3, RAC, KH1, KH2^2)
\]

where

- $i = B, BS, or TCH$;
- $EXP =$ weekly expenditure on all foods;
- $Y =$ annual household income (in dollars);
- $EDHM =$ 1 if household manager not college educated, 0 otherwise;
- $EMPHSM =$ 1 if household manager unemployed, 0 otherwise;
- $SXHM =$ 1 if household manager female, 0 otherwise;
- $AGHM =$ 1 if household manager less than 35 years of age, 0 otherwise;
- $R1 =$ 1 if household located in the Northeast, 0 otherwise;
- $R2 =$ 1 if household located in the North Central, 0 otherwise;
- $R3 =$ 1 if household located in the West, 0 otherwise;
- $U1 =$ 1 if household located in central city, 0 otherwise;
- $U2 =$ 1 if household located in nonmetropolitan area, 0 otherwise;
- $S1 =$ 1 if season spring (April–June 1977), 0 otherwise;
- $S2 =$ 1 if season fall (October–December 1977), 0 otherwise;
- $S3 =$ 1 if season winter (January–March 1978), 0 otherwise; and
- $RAC =$ 1 if household head black or non-white, 0 otherwise.

The variables $EXP, Y,$ and $KH_i$ are continuous, whereas all remaining variables are discrete. The base or omitted category for region is the South, the omitted category for population density is the suburban area, and the omitted category for season is the summer. If the meal planner is the female household head only, the female head and the male head, or the female head and someone else, then the female head is the household manager. If the meal planner is either the male household head only or the male head and someone else, then the male head is the household manager. The square of the household equivalent scale is introduced to account for the possible existence of economies of size (Price, Buse and Salathe). Inclusion of the sociodemographic variables in the Engel functions reflects the recognition of heterogenous tastes and preferences. Consequently, in the construction of the adult equivalent scales, tastes and preferences are controlled.

Approximately 15,000 households located in the contiguous states are included in the
NFCS. This analysis includes data from usable schedules for 9,204 households. Households excluded are those that did not report relevant income or sociodemographic information. Additionally, only housekeeping households, defined as those households with at least one person having ten or more meals from the household supply during the survey period, are included in the analysis. Sample selection bias does not appear to be a problem because the frequencies for the usable sample are quite similar to the frequencies for the overall sample. Descriptive statistics of all variables used in the analysis are available from the authors upon request.

Estimates of the scale parameters for each of the models are constrained to be equal both for \( KH \) and \( KH^2 \), thereby necessitating the use of a nonlinear estimation procedure. A nonlinear regression algorithm using Marquardt's compromise (Draper and Smith) is used to estimate the parameters of the Engel functions.

**Empirical Results**

The estimates of the adult scale parameters, using the Engel function specification in (4), for each of the three models are exhibited in Table 4. The estimate of the scale parameter for a female seventeen to twenty-two years of age in the TCH model (.7401) corresponds closely to the estimate of the parameter for a female twenty to fifty-five years of age in the Buse-Salathe model (.7439) and to the estimate of the parameter for a female twenty years of age and beyond in the Blokland model (.7573). These respective estimates are roughly 25% below and significantly different from the value of the standard household member. In addition, the estimates for this group of elderly females are approximately 30% to 45% below and significantly different from the value of the standard household member. Because the parameter estimate of \( u \) is statistically different from one and because the estimate of \( v \) is statistically different from \( \gamma_{RS} \), the Buse-Salathe life cycle age-class specification is inconsistent with the Blokland life cycle age-class specification. In short, the former specification is more general than the latter.

In the TCH model, the parameter estimates of \( M3 \) and \( M4 \) indicate that the scale values for males either in the middle or late adult transitional periods are not significantly different from the standard household member in the early adult transitional period. Also, the parameter estimates of \( F3 \) and \( F4 \) indicate that the scale values for females either in the middle or late adult transitional periods are not significantly different from females in the early adult transitional period. The adult equivalent scale parameter estimates in the TCH model indicate that food expenditure behavior is different for males and females within the same developmental and transitional stages of the life cycle. In agreement with the Buse-Salathe model, the coefficients in the TCH model associated with the cubic functions postulated for the developmental periods are, with the exception of \( E41 \), not significantly different from zero. Consequently, the scale functions could have been specified as strict monotonic functions of age for all developmental periods other than during late adulthood for males. These findings for the TCH model, despite differences in the age-class delineations, tend to be similar to those based on the Buse-Salathe life cycle specification. The Buse-Salathe model, however, lacks the explicit rationale of the TCH model.

The estimates of the coefficients associated with the sociodemographic variables in the Blokland, Buse-Salathe, and TCH models are exhibited in Table 5. With few exceptions, the magnitudes and signs of the estimated coefficients are very similar for the various models. Income \( (Y) \), the number of adult equivalents \( (KH) \), the number of adult equivalents squared \( (KH^2) \), employment status of the household manager \( (EMPSHM) \), age of the household manager \( (AGHM) \), geographic location \( (R1, R2, R3) \), urbanization \( (U1, U2) \), and seasonality \( (S1, S2, S3) \) are key determinants of household food expenditure. The significant negative value for \( KH^2 \) points to
Table 4. Estimates of the Adult Scale Parameters for the TCH Model, the Buse-Salathe Model, and the Blokland Model

<table>
<thead>
<tr>
<th>Parameter</th>
<th>TCH Model</th>
<th>Buse-Salathe Model</th>
<th>Blokland Model</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Estimate (Standard Error)</td>
<td>Parameter</td>
<td>Estimate (Standard Error)</td>
</tr>
<tr>
<td>M1</td>
<td>0.3868(^*) (0.0734)</td>
<td>(\epsilon_{BS})</td>
<td>0.3559(^*) (0.0632)</td>
</tr>
<tr>
<td>M3</td>
<td>0.9892(^*) (0.0555)</td>
<td>(\gamma_{BS})</td>
<td>0.7439(^*) (0.0367)</td>
</tr>
<tr>
<td>M4</td>
<td>0.9551(^*) (0.0665)</td>
<td>(\delta_{BS})</td>
<td>0.0256 (0.0203)</td>
</tr>
<tr>
<td>M5</td>
<td>0.8035(^*) (0.0834)</td>
<td>(\lambda_{BS})</td>
<td>0.0358 (0.0206)</td>
</tr>
<tr>
<td>F2</td>
<td>0.7401(^*) (0.0386)</td>
<td>(u)</td>
<td>0.7280(^*) (0.0526)</td>
</tr>
<tr>
<td>F3</td>
<td>0.8575(^*) (0.0605)</td>
<td>(v)</td>
<td>0.5659(^*) (0.0549)</td>
</tr>
<tr>
<td>F4</td>
<td>0.7674(^*) (0.0654)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F5</td>
<td>0.7051(^*) (0.0751)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E11</td>
<td>0.0144 (0.0282)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E21</td>
<td>0.0012 (0.0072)</td>
<td>(-0.0004) (0.0097)</td>
<td></td>
</tr>
<tr>
<td>E31</td>
<td>0.0357 (0.0279)</td>
<td>(E_{32})</td>
<td>0.0133 (0.0077)</td>
</tr>
<tr>
<td>E41</td>
<td>0.0222(^*) (0.0086)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E12</td>
<td>0.0357 (0.0279)</td>
<td>(E_{41})</td>
<td>0.0091 (0.0072)</td>
</tr>
<tr>
<td>E22</td>
<td>0.0133 (0.0077)</td>
<td>(E_{41})</td>
<td>0.0091 (0.0072)</td>
</tr>
<tr>
<td>E32</td>
<td>(-0.0133) (0.0090)</td>
<td>(E_{41})</td>
<td>0.0091 (0.0072)</td>
</tr>
<tr>
<td>E42</td>
<td>(-0.0091) (0.0072)</td>
<td>(E_{41})</td>
<td>0.0091 (0.0072)</td>
</tr>
<tr>
<td>(R^2)</td>
<td>.4947</td>
<td>.4936</td>
<td>.4908</td>
</tr>
</tbody>
</table>

Asterisk indicates parameter estimate at least twice the associated standard error.

the existence of economies of size for household food expenditure. The estimates for \(Y\), \(KH\), and \(KH^2\) are slightly smaller in the TCH model vis-à-vis the Blokland and Buse-Salathe models. The income elasticity for food, at the sample means, ranges from .0938 in the TCH model to .1094 in the Blokland model. The household equivalent scale elasticity for food ranges from .7163 in the Buse-Salathe model to .7468 in the TCH model. In the expenditure on food, households are more sensitive to changes in age-sex composition than to changes in income.

Households located in the Northeast, the North Central region, and the West, expend on the average close to $7.00, $1.25, and $1.50 more per week on food than households located in the South. Households spend roughly $2.00 less per week in the spring and $1.40 less per week in the fall on food than in the summer. No significant differences in household food expenditure exist between the summer and winter seasons. Households located in central cities expend approximately $1.20 more per week on food than households located in suburban areas, while households located in nonmetropolitan areas expend approximately $1.20 less per week on food than households located in suburban areas. Households wherein household managers are unemployed and greater than thirty-five years of age spend more on food per week than their corresponding counterparts. Sex of the household manager, education of the household man-
Table 5. Estimates of the Coefficients Associated with the Sociodemographic Variables in the Blokland Model, the Buse-Salathe Model, and the TCH Model

<table>
<thead>
<tr>
<th>Variable</th>
<th>Blokland Model</th>
<th>Buse-Salathe Model</th>
<th>TCH Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTERCEPT</td>
<td>2.3842 (1.2135)</td>
<td>4.1068* (1.2343)</td>
<td>3.9345* (1.2461)</td>
</tr>
<tr>
<td>Y</td>
<td>0.3954E-03** (0.0331E-03)</td>
<td>0.3420E-03* (0.0338E-03)</td>
<td>0.3391E-03* (0.0352E-03)</td>
</tr>
<tr>
<td>EDHM</td>
<td>0.8091 (0.4830)</td>
<td>0.7737 (0.4819)</td>
<td>0.6296 (0.4844)</td>
</tr>
<tr>
<td>EMPHSM</td>
<td>1.3452* (0.4382)</td>
<td>2.1263* (0.4514)</td>
<td>1.9750* (0.4547)</td>
</tr>
<tr>
<td>SXHM</td>
<td>0.3830 (0.9076)</td>
<td>0.4654 (0.9211)</td>
<td>-0.4190 (1.0010)</td>
</tr>
<tr>
<td>AGHM</td>
<td>-1.1379* (0.5488)</td>
<td>-2.1629* (0.5665)</td>
<td>-1.2412 (0.6446)</td>
</tr>
<tr>
<td>R1</td>
<td>6.9795* (0.5439)</td>
<td>6.9780* (0.5425)</td>
<td>6.9602* (0.5426)</td>
</tr>
<tr>
<td>R2</td>
<td>1.2395* (0.5409)</td>
<td>1.2379* (0.5395)</td>
<td>1.2562* (0.5398)</td>
</tr>
<tr>
<td>R3</td>
<td>1.4856* (0.6175)</td>
<td>1.5173* (0.6161)</td>
<td>1.4653* (0.6165)</td>
</tr>
<tr>
<td>U1</td>
<td>1.2369* (0.5246)</td>
<td>1.1717* (0.5234)</td>
<td>1.1747* (0.5234)</td>
</tr>
<tr>
<td>U2</td>
<td>-1.1282* (0.4956)</td>
<td>-1.1522* (0.4945)</td>
<td>-1.2295* (0.4945)</td>
</tr>
<tr>
<td>S1</td>
<td>-2.0245* (0.5842)</td>
<td>-2.0433* (0.5827)</td>
<td>-2.0715* (0.5826)</td>
</tr>
<tr>
<td>S2</td>
<td>-1.4032* (0.5667)</td>
<td>-1.3426* (0.5653)</td>
<td>-1.3650* (0.5656)</td>
</tr>
<tr>
<td>S3</td>
<td>-1.0656 (0.5706)</td>
<td>-1.0401 (0.5691)</td>
<td>-1.0478 (0.5692)</td>
</tr>
<tr>
<td>RAC</td>
<td>0.0293 (0.6200)</td>
<td>-0.2976 (0.6207)</td>
<td>-0.3565 (0.6222)</td>
</tr>
<tr>
<td>KH</td>
<td>16.3559* (0.6077)</td>
<td>16.6148* (0.6529)</td>
<td>15.9698* (0.7685)</td>
</tr>
<tr>
<td>KH²</td>
<td>-0.4620* (0.0824)</td>
<td>-0.5139* (0.0871)</td>
<td>-0.4379* (0.0920)</td>
</tr>
</tbody>
</table>

* Asterisk indicates parameter estimate at least twice the associated standard error.

Aging, and race of the household head are not statistically important determinants of household food expenditure.

Plots of the male and female adult equivalent scales for the Blokland, Buse-Salathe and TCH models are presented in figure 1. Because of the imposed prior restrictions, neither the Blokland model nor the Buse-Salathe model possesses the variability in scale values of the TCH model.

The three equivalent scales for males are very similar up to sixty years of age. Thereafter, while both the TCH and Buse-Salathe scales decrease during the late developmental years, the TCH scale for males exceeds the corresponding Buse-Salathe scale. On the other hand, the equivalent scales for females are vastly different, at least after approximately twenty-two to twenty-five years of age. The TCH scale for females exceeds the respective Buse-Salathe and Blokland scales for females for each year beyond age twenty-two. The TCH scale for females rises sharply during the period of early adulthood and again during the early years of the middle adult developmental stage. After roughly forty-eight years of age, the TCH scale for females declines in monotonic fashion.

On the whole, unlike the Blokland and Buse-Salathe models, the life cycle pattern in the TCH model for females is quite different from the life cycle pattern for males. Comparison of the male and female life cycle profiles in figure 1 suggests that the adult equivalent scale specification by Blokland may be too restrictive. The TCH and the Buse-Salathe specifications are reasonably similar, although noticeable differences exist in the equivalent
Concluding Remarks

This paper presents a continuous adult equivalent scale model, the TCH model, where specifications for the age classes and for the life cycle concept are explicitly based upon research findings and concepts from the fields of psychology as well as from child and human development. The Blokland and Buse-Salathe models, popular continuous equivalent scale specifications, lack the explicit rationale of the TCH model and are inconsistent with the life cycle developmental concepts underlying the TCH model. Based on analysis of data for weekly time periods from the 1977–78 Nationwide Food Consumption Survey, food expenditure behavior for males and females is generally different at various developmental and transitional stages of the life cycle. This finding in regard to economic behavior is quite consistent with the research findings obtained in studies of other types of human behavior.

The estimates of the scale parameters in the TCH model suggest that the Blokland model is too restrictive to portray adequately consumer behavior over the life cycle. However, despite differences in the age-class delineations and despite the fact that the TCH model constitutes a more general specification than the Buse-Salathe model, the empirical findings based on the TCH model in this research tend to be similar to those based on the Buse-Salathe model.

[Received January 1985; final revision received July 1985.]

References


Appendix

Expressions for Variable Calculation

**Table A1. Expressions for the Weighted Sum Variables in the Blokland Model**

\[
P_B = n_2 + .0075 \sum_{j=1}^{n_1} a_j^2 - .00025 \sum_{j=1}^{n_1} a_j^3
\]

\[
Q_B = n_4 + .0075 \sum_{j=1}^{n_2} a_j^2 - .00025 \sum_{j=1}^{n_2} a_j^3
\]

\[
R = n_1 + n_3 - .0075 \left[ \left( \sum_{j=1}^{n_1} a_j^2 + \sum_{j=1}^{n_2} a_j^2 \right) \right] + .00025 \left[ \left( \sum_{j=1}^{n_1} a_j^3 + \sum_{j=1}^{n_2} a_j^3 \right) \right]
\]

\[
S = \sum_{j=1}^{n_1} a_j - .1 \sum_{j=1}^{n_3} a_j^2 + .0025 \sum_{j=1}^{n_3} a_j^3
\]

\[
T = \sum_{j=1}^{n_1} a_j - .1 \sum_{j=1}^{n_3} a_j^2 + .0025 \sum_{j=1}^{n_3} a_j^3
\]

where \(a_j\) = the age of the \(j\)th household member, \(n_1\) = the number of males 0 to 20 years of age, \(n_2\) = the number of males at least 21 years of age, \(n_3\) = the number of females 0 to 20 years of age, and \(n_4\) = the number of females at least 21 years of age.

**Table A2. Expressions for the Weighted Sum Variables in the Buse-Salathe Model**

\[
P_{BS} = (n_2 + n_4) + .0075 \left[ \left( \sum_{j=1}^{n_1} a_j^2 - \sum_{j=1}^{n_3} (a_j - 55)^2 \right) \right] - .00025 \left[ \left( \sum_{j=1}^{n_1} a_j^3 - \sum_{j=1}^{n_3} (a_j - 55)^3 \right) \right]
\]

\[
Q_{BS} = (n_4 + n_5) + .0075 \left[ \left( \sum_{j=1}^{n_1} a_j^2 - \sum_{j=1}^{n_3} (a_j - 55)^2 \right) \right] - .00025 \left[ \left( \sum_{j=1}^{n_1} a_j^3 - \sum_{j=1}^{n_3} (a_j - 55)^3 \right) \right]
\]

\[
R = (n_1 + n_3) - .0075 \left[ \left( \sum_{j=1}^{n_1} a_j^2 + \sum_{j=1}^{n_3} a_j^2 \right) \right] + .00025 \left[ \left( \sum_{j=1}^{n_1} a_j^3 + \sum_{j=1}^{n_3} a_j^3 \right) \right]
\]

\[
S = \left[ \left( \sum_{j=1}^{n_1} a_j - .1 \right) \sum_{j=1}^{n_3} a_j^2 + .0025 \sum_{j=1}^{n_3} a_j^3 \right]
\]

\[
T = \left[ \left( \sum_{j=1}^{n_1} a_j - .1 \right) \sum_{j=1}^{n_3} a_j^2 + .0025 \sum_{j=1}^{n_3} a_j^3 \right]
\]

\[
U = \left[ \left( n_6 + .0075 \sum_{j=1}^{n_3} (a_j - 55)^2 \right) - .00025 \sum_{j=1}^{n_3} (a_j - 55)^3 \right]
\]

\[
V = \left[ \left( n_8 + .0075 \sum_{j=1}^{n_3} (a_j - 55)^2 \right) - .00025 \sum_{j=1}^{n_3} (a_j - 55)^3 \right]
\]

where \(a_j\) = the age of the \(j\)th household member, \(n_1\) = the number of males 0 to 20 years of age, \(n_2\) = the number of males 21 to 55 years of age, \(n_3\) = the number of females 0 to 20 years of age, \(n_4\) = the number of females 21 to 55 years of age, \(n_5\) = the number of males 56 to 75 years of age, \(n_6\) = the number of males at least 76 years of age, \(n_7\) = the number of females 56 to 75 years of age, and \(n_8\) = the number of females at least 76 years of age.
Table A3. Expressions for the Weighted Sum Variables in the TCH Model

\[
VA = n_1 + n_9 - 0.010381 \sum a_j^2 + 0.0004071 \sum a_j^3 - 0.010381 \sum a_j^2 + 0.0004071 \sum a_j^3
\]

\[
VB = n_2 + n_3 - 0.010381 \sum a_j^2 + 0.0004071 \sum a_j^3 - 0.0092593 \sum (a_j - 22)^2 + 0.003429 \sum (a_j - 22)^3
\]

\[
VC = n_4 + n_5 + 0.0092593 \sum (a_j - 22)^2 - 0.0003429 \sum (a_j - 22)^3 - 0.0133333 \sum (a_j - 45)^2 + 0.005926 \sum (a_j - 45)^3
\]

\[
VD = n_6 + n_7 + 0.0133333 \sum (a_j - 45)^2 - 0.0005926 \sum (a_j - 45)^3 - 0.0133333 \sum (a_j - 65)^2 + 0.005926 \sum (a_j - 65)^3
\]

\[
VE = n_8 + 0.0133333 \sum (a_j - 65)^2 - 0.0005926 \sum (a_j - 65)^3
\]

\[
VF = n_{10} + n_{11} + 0.010381 \sum a_j^2 - 0.0004071 \sum a_j^3 - 0.0092593 \sum (a_j - 22)^2 + 0.003429 \sum (a_j - 22)^3
\]

\[
VG = n_{12} + n_{13} + 0.0092593 \sum (a_j - 22)^2 - 0.0003429 \sum (a_j - 22)^3 - 0.0133333 \sum (a_j - 45)^2 + 0.005926 \sum (a_j - 45)^3
\]

\[
+ 0.0005926 \sum (a_j - 45)^3
\]

\[
VH = n_{14} + n_{15} + 0.0133333 \sum (a_j - 45)^2 - 0.0005926 \sum (a_j - 45)^3 - 0.0133333 \sum (a_j - 65)^2 + 0.005926 \sum (a_j - 65)^3
\]

\[
+ 0.0005926 \sum (a_j - 65)^3
\]

\[
VI = n_{16} + 0.0133333 \sum (a_j - 65)^2 - 0.0005926 \sum (a_j - 65)^3
\]

\[
VJ = \sum a_j - 0.1176469 \sum a_j^2 + 0.0034602 \sum a_j^3
\]

\[
VK = \sum (a_j - 22) - 0.1176469 \sum (a_j - 22)^2 + 0.0034602 \sum (a_j - 22)^3
\]

\[
VL = \sum (a_j - 45) - 0.1333333 \sum (a_j - 45)^2 + 0.0044444 \sum (a_j - 45)^3
\]

\[
VM = \sum (a_j - 65) - 0.1333333 \sum (a_j - 65)^2 + 0.0044444 \sum (a_j - 65)^3
\]

\[
VN = \sum a_j - 0.1176469 \sum a_j^2 + 0.0034602 \sum a_j^3
\]

\[
VO = \sum (a_j - 22) - 0.1176469 \sum (a_j - 22)^2 + 0.0034602 \sum (a_j - 22)^3
\]

\[
VP = \sum (a_j - 45) - 0.1333333 \sum (a_j - 45)^2 + 0.0044444 \sum (a_j - 45)^3
\]

\[
VQ = \sum (a_j - 65) - 0.1333333 \sum (a_j - 65)^2 + 0.0044444 \sum (a_j - 65)^3
\]

where \(a_j\) is the age of the \(j\)th household member, \(n_1\) is the number of males 0 to 17 years of age, \(n_2\) is the number of males 18 to 22 years of age, \(n_3\) is the number of males 23 to 40 years of age, \(n_4\) is the number of males 41 to 45 years of age, \(n_5\) is the number of males 46 to 60 years of age, \(n_6\) is the number of males 61 to 65 years of age, \(n_7\) is the number of males 66 to 80 years of age, \(n_8\) is the number of males at least 81 years of age, \(n_9\) is the number of females 0 to 17 years of age, \(n_{10}\) is the number of females 18 to 22 years of age, \(n_{11}\) is the number of females 23 to 40 years of age, \(n_{12}\) is the number of females 41 to 45 years of age, \(n_{13}\) is the number of females 46 to 60 years of age, \(n_{14}\) is the number of females 61 to 65 years of age, \(n_{15}\) is the number of females 66 to 80 years of age, and \(n_{16}\) is the number of females at least 81 years of age.