CARE WORK AND THE ECONOMY

Advancing policy solutions with gender-aware macroeconomic models

METHODOLOGICAL REPORT FOR PROJECTING DEMAND AND SUPPLY IN THE CARE ECONOMY: UNITED STATES & SOUTH KOREA

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CWE-GAM METHODOLOGICAL REPORT

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THE CARE WORK AND THE ECONOMY (CWE-GAM) PROJECT

The Care Work and the Economy (CWE-GAM) Project strives to reduce gender gaps in economic outcomes and enhance gender equality by illuminating and properly valuing the broader economic and social contributions of caregivers and integrating care in macroeconomic policymaking toolkits. We work to provide policymakers, scholars, researchers, and advocacy groups with gender-aware data, empirical evidence, and analytical tools needed to promote creative, gender-sensitive macroeconomic and social policy solutions. In this era of demographic shifts and economic change, innovative policy solutions to chronic public underinvestment in care provisioning and infrastructures to address the constraints that care work imposes on women's life and employment choices are needed more than ever. Sustainable development requires gender-sensitive policy tools that integrate emerging understandings of care work and its connection with labor supply, and economic and welfare outcomes.

Find out more about the project at www.careworkeconomy.org.

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Table of Contents

1. Overview

This report outlines the data and methods for a simple projection of the care economy, applied to the United States and Korea. It is meant to be a flexible tool that any country with survey data on time use, labor force participation, and consumer expenditures can use to understand the current state of the care economy and project it forward in time. The results can be used to evaluate how projected changes in population age structure may impact the balance between the supply and demand for different types of care. It can also be adapted to evaluate other types of change, although here the focus will be on population age structure changes.

The work here is innovative in several respects. It includes the whole care economy: unpaid care work (UCW) provided for no pay by family, household, and community members, and paid care work (PCW) provided by market-based providers who are paid by the care recipient, care recipient's family, or by government for the benefit of the care recipient. For the PCW economy, two types are recognized: less credentialed workers, whose jobs may require some training but not a particular advanced degree, and more credentialed workers where employment typically requires years of post-secondary and tertiary education as well as licenses granted by a regulatory body. For UCW, it is defined here to include direct care resources that are targeted to children, adults, and elders and involve in-person interaction, but also indirect care that benefits household and community members but does not involve direct interaction. Examples of this type of indirect UCW include general housework, household management and volunteering in the community.

Another way this approach is innovative is its treatment of age. Estimates of care production and consumption are created by single year of age, separated by gender. It is more common in explorations of the care economy to see results in large age groups summarizing life stages such as children, working age, and elderly. This general age group approach is useful for some purposes and for simplifying results, but for cross-country comparative work it can obscure important differences in life course patterns across countries. The nature of the care economy is driven by demographic phenomena that vary by age such as birth, marriage, aging, and death. Retaining the single years of age detail reveals the way the demography shapes the care economy and allows the results to be impacted by the ways in which the timing of life course events varies from country to country.

The analysis is flexible and built with an eye toward future replication in other countries. which will have different types of data available and different ideas about what future scenarios are reasonable to envision. To enable this replication, a premium is placed on using data which will be broadly similar in many countries that have time use, labor force, and consumption surveys. Simplicity and flexibility in the methods are also prioritized. The first goal is to give access to an overall picture of the care economy to the widest audience possible, including policymakers, civil society, media, and the public. The second goal is to

combine that picture with population projects to give the simplest projection of the care economy possible. The model described here does not include any potential interactions over time between population and the care economy, which is certainly an oversimplification compared to the likely reality. However, what the model lacks in detail, it makes up for in accessibility to a broad audience who may find more sophisticated models to be a "black box" with results they do not understand well or trust.
The methodology here is discussed using data from the United States and South Korea as example applications. The computer programs are all written in Stata code.
The analysis is modular, with three separate pieces which can each have different versions. Combining the different versions across these modular pieces allows for sensitivity analyses to underlying assumptions and gives some indication of the range of possible outcomes and which factors drive the outcomes. The three pieces are as follows:

1. Current snapshot of the per capita care economy. The care economy is characterized by sex-specific age profiles by single years of age of the production and consumption of paid and unpaid care work in one time period.[1]
2. Population projections. Existing projections of counts of persons by age and sex, annually from the year of the snapshot to a particular endpoint in time. For the examples shown here, the projections will cover 2020 to 2050. In most contexts, the longer the time period, the greater the impact will be for population changes on the balance of care supply and demand.
3. Model of per capita care economy change over time. The projection will proceed by weighting care economy age profiles by changing population counts by age and sex. Different models of how the per capita age profiles can change from year to year create different projected aggregates of care production and consumption over time. These production and consumption estimates serve as estimates of care supply and demand. The model of the care economy that will be used in this set of examples is that the per capita age/sex patterns of care production and consumption are constant over time. Another model may be that the unpaid care work economy is constant by per capita age/sex groups, but the paid care work age profiles will adjust to fill any unmet demand for care services beyond what the unpaid care side is providing. Many other potential models will be discussed in Section 4 on "Future extensions of this work."

The rest of this document details the data and methods for creating the snapshot of the care economy, followed by two different sources of population projections.

[1] For these purposes, an "age profile" is defined as a set of nationally representative averages by age of some flow of care. Averages by single years of age up to a maximum age groups of 90+ (data permitting) are calculated and then smoothed over age to create the final age profile used in the results presentations and projections. Also, with this analysis combining UCW and PCW sectors the most recent survey data sources that cover those sectors may be from different time periods. The closer in time the better for the analysis, but if the time periods covered by the survey data are at least within a few years of each other and no major disruptions have happened in the economy or society, then the comparison should still be reasonable.

2. Methods and Data for US and Korea

2.1 Creating the current snapshot of the care economy

2.1.1 UCW production

The unpaid care work estimates follow National Time Transfer Accounts (NTTA) methodology, developed by the National Transfer Accounts and Counting Women's Work projects (Donehower, 2019). To summarize, the NTTA's start with household production satellite accounting methodology to measure and value unpaid care work (Abraham & Mackie, 2005) and combine it with National Transfer Accounts (NTA) project methodology (United Nations, 2013) to disaggregate national accounts by age. Finally, there is a disaggregation of all age profiles by sex, which was not part of the original NTA methodology, but which express the gender data perspective at the heart of this work.

The data to estimate unpaid care work (UCW) come from time use surveys. If the time use data comes from a full diary survey, the total amount of time spent on each of the following six activities is identified in whatever coding structure is used to classify activities. The distinction between work and non-work for unpaid care activities follows the "third person criterion" (Reid, 1934) that an activity is work if you could pay someone else to do it for you and still get the benefit of the activity. Thus, shopping is defined as work but sleeping is not. The six groups of UCW activities are:

1. general housework including cooking, cleaning, laundry, and all the other activities of day-to-day household maintenance and management,
2. direct care for household children
3. direct care for household adults and elders
4. direct care for non-household children
5. direct care for non-household adults and elders
6. direct care for community members through volunteering

For some research purposes, more detailed classifications could be used identifying more separate age profiles.

Once the six activity groups are identified, the time use activity data is transformed so that there is a line in the dataset for each time use respondent, with variables showing the total time each respondent spent in each of the six activity groups. This transformed individual-level data is then collapsed to age- and sex-specific mean times spent. (The individual-level file should be saved before calculating the means by age and sex because it will be used in the consumption calculation.)

Finally, a weighted cross-validation smoother (Friedman, 1984) is used to get a smooth age-schedule of average time spent, for each sex separately. The weights are the number of survey observations in each age group. This allows the smoother to give more weight to age groups with more observations and thus a lower uncertainty of the overall estimate. The smoothing reduces noise in the overall age shape and gives more consistent patterns when comparing across countries or across groups within a county.

Data specifics: US

Data for the United States comes from the American Time Use Survey ATUS-X facility that is part of IPUMS (Hofferth et al., 2018, https://www.atusdata.org/atus/). One extract is created for activities of time use respondents and another with the characteristics of respondents including age, sex, and any other characteristics of interest. (For the consumption estimates discussed in the next section, a third file is needed with the full household roster. This will be discussed in more detail in the section on UCW consumption.) Once the activity file is transformed into an estimate of the time spent on the six UCW activity groups, the characteristics are merged by individual identifier. The specific activity codes used in the ATUS that are in each of the six UCW activity groups are given in Table 1 for the US, Table 2 for Korea.

Table 1. Activity codes in NTTA UCW estimates for the US from the ATUS

UCW Activity	ATUS Activity Codes
General housework	(cleaning) 20101, (laundry) 20102, 20103, (cooking) 20201-20299, (household maintenance) 20301-20499, 20701-20899, (lawn & garden care) 20501-20599, (household management) 20104, 20199, 20901-29999, 160103-160108, (pet care) 20601-20699, (travel related to care and purchasing goods & services) 180201-180499, 180701-180999, 181501-181599, (purchasing goods & services) 70101-7999, 80101-80199, 80601-80799, 90101-99999, 100103
Care of household children	30101-30399
Care of non-household children	40101-40399
Care of household adults and elders	30401-39999
Care of non-household adults and elders	40401-49999
Community care through volunteering	150101-159999

Data specifics: Korea

Data for the Republic of Korea comes from the Korean Time Use Survey for 2014.

Table 2. Activity codes in NTTA UCW estimates for the Korea from the KTUS

UCW Activity	ATUS Activity Codes
General housework	(cleaning) D320, D340, D360, (laundry) D220, D240, (cooking) D120, D140, D160, (household maintenance) D420, D440, D520, (lawn & garden care) D640, (household management) D920, D940, D960, D990, (pet care) D620, (travel related to care and purchasing of goods & services) H420, H520, H540, H720, (purchasing goods & services) D720, D740, D760, D780, D790, D180, D280, D460, D480, D540, D660

Care of household children	E120, E140, E160, E180, E190, E220, E240, E260, E290
Care of non-household children	Not available in KTUS
Care of household adults and elders	E320, E390, E420, E490, E520, E590
Care of non-household adults and elders	E620, E690
Community care through volunteering	E720, E790, F220, F240, F290, F320, F340, F360, F390

Other issues

Many have argued that in any estimate of UCW, it is crucial to understand the role of supervisory care (Suh & Folbre, 2016). This is time that a caregiver is responsible for a dependent's safety and wellbeing but is not actively engaged with that dependent. The time a baby is sleeping is one example. Some of the time a caregiver may spend in the house of an elder with dementia is another example – the caregiver must be alert so that the person does not wander off, but they may not be actively engaged with that person the entire time. Given that supervisory time is an important responsibility and a legal obligation in some contexts it certainly seems to qualify as unpaid care work. If you could not stay home with a sleeping infant, you would have to hire a babysitter or have someone else take over that work for you. If women are more likely to be responsible for supervisory time than men, the amount of supervisory time required would be an important constraint on women's ability to use their time for other things.

While the theoretical importance of supervisory time is clear, unfortunately its measurement is not. Many time use surveys include ways to evaluate this type of care but these ways are often very different. For example, the ATUS asks for each activity a respondent names whether the respondent was also responsible for any children aged 12 or younger at the time. Other surveys give respondents the opportunity to name a primary activity and a secondary activity, or multiple activities that may have been taking place simultaneously but without any indication of ranking of importance or focus. The diversity of survey instruments to measure this type of care makes including it in a cross-country comparative way very difficult.

To begin to understand supervisory care, this project includes an alternate analysis of the ATUS item on whether an activity was done while the respondent was responsible for a child aged 0-12. Where there is supervisory care for children, we divide the time unit 50/50 between the activity coded for that time unit and childcare. This keeps the estimates scaled to 24 hours accounted for per person and accords with the growing body of research that "multitasking" really does not constitute a gain in productivity over sequential activities. Cooking while supervising young children can be expected to take more time than cooking alone. Once the 50/50 adjustment is made, the rest of the calculations are the same as for the estimates using the main activity only.

Future explorations of Korea's care economy will include the simultaneous activity data collected in the Korean Time Use Survey. Unfortunately, given the very different nature of the survey items – the US survey prompts for simultaneous childcare specifically while the

Korean survey prompts for any simultaneous activities – the comparison will reveal either how different supervisory care is in the two countries or how the different survey instruments measure the concept. Separating those two effects, however, may not be possible. At the least, it highlights the urgent need for a standard method to emerge.

2.1.2 UCW consumption

While time use surveys directly query the production of UCW time, there is no direct measure of the consumption of time. Time use surveys are not of those who consume UCW time, but rather of those who produce it. Some time use surveys collect data on who was with the UCW producer at the time, which would allow direct identification of the consumer of any time produced. Most surveys do not have this level of detail, though, so we rely on indirect measures to impute the UCW produces as the consumption of particular persons, first in the household and then, if there is any UCW produced for persons outside of the household, those amounts are imputed to the general population.

For the imputation to household members, we need additional data on who lives in the household other than the time use respondent in other words a household roster listing the age and sex of each household member. In some surveys, all adults are asked to be time use respondents, in other surveys some subset of the household gives time use information. The household roster contains information on all household members whether they are time use respondents or not.

The household roster must include:

- Age by single years, up to 85+ or 90+ depending on what is available in the survey
- Sex
- Unique household ID (this will be to merge with the activity data)
- Unique person ID within each household
- Survey weights that will allow the collapse of the individual-level microdata to nationally-representative means by age and sex that represent an "average" day
- For future work disaggregating care consumption estimates by more relevant covariates, we want to also include any available measure of health status, disability, cognitive impairment or any diagnosis that would likely affect how much care the person needed. (The American Time Use Survey has self- or proxy-reported indicators of whether or not the person was experiencing various types of impairments.) This work will not use those covariates at this time, but in future iterations it will be relevant to have these variables examined while doing the basic work of merging the household roster with time use information.

Given the sample of time produced, we use assumptions and data-driven techniques to impute the consumption of each type of UCW produced to consumers. For general household activity consumed by household members, that consumption is assumed to be equally shared by all family members. As an example of what this means in practice, if an UCW producer in a household with four members (including the UCW producer) produces

an average of one hour of cooking per day, that production is imputed as 15 minutes of consumption by each household members, including 15 minutes for the producer himself.

For direct care activities within the household this equal allocation would not be reasonable. The very young and very old consume much more in direct care than those in mid-life. Instead of the equal allocation method, we use a regression approach that uses the association between care production and household structure to create care consumption weights by age and sex. These weights are applied to household care produced in order to apportion the amount of direct care produced in a household to the individuals within that household.

Specifically, if households are observed to each produce some amount of childcare, we estimate a household-level regression model on the survey data for each producer of direct care. We regress that producer's amount of childcare produced on the number of household members in each child age/sex group. The regression coefficients on each age and sex group then become weights that can be used to apportion the household amount of childcare produced in each household by each time use respondent to each child in that household. Similarly for adult care, we regress the household production of adult care by each time use respondent and number of adults in each age/sex group. Note that for either type of care, the producer of the care is not included in the household structure data that goes into the regression estimation even if he or she is in the target age group because he or she is not a potential target of the care. (The coding of self-care is different in all activity schemes from care for other persons.) This regression approach is limited because it relies only on detecting variability between households of different age and sex composition and cannot detect differences within households where individuals of similar age and sex may actually receive different levels of care. This is most relevant as regards to the sex differences in care consumption estimates. Our ability to detect different amounts of care given to close-age males and females sharing the same household is minimal. Overall, then, our estimates here of sex differences in care consumption must be considered a lower bound.

To be more specific about the regression method for imputing consumption, a regression equation is estimated for each potential care producer (that is, for each household member who was asked to fill out the time use survey questionnaire) and for each type of direct care as follows:

$$X_j = \sum_a \sum_s \alpha(a,s) E_j(a,s) + \varepsilon_j$$

the producer's time produced to household members as consumption. If a particular age/ sex group has a coefficient less than zero, this is the data saying that households with persons in this age/sex group do not seem to produce any more care than other households. Given that, the weight should be set to zero rather than the negative number. This may cause a few households to have unallocated care. These amounts should be very small or it indicates a possible problem with the regression implementation. The small amounts can be recoded as care for non-household members.

For direct care that is consumed by non-household persons, the aggregate amount of care produced is allocated using the relative overall age/sex profiles of consumption for household children or adults. In other words, I know the size of this type of care produced from the production profiles weighted by total population. That aggregate flow is imputed to consumers by age and sex in the same relative amounts as the overall age profile for in-household consumption of that type of care. For volunteering, the aggregate amount produced is imputed to consumers on a per capita basis (i.e. an age profile that is a straight line across age, the same level for both sexes).

Note that the system of allocating care provided within the household to persons in the target age group runs the risk of having time that should go to a child or elder, but there turns out to be no child or elder in the household. In both the US and Korean cases examined here, that number is relatively small, but it does come up as unallocated care consumption which means that the aggregate and household-level equality between consumption and production is violated. In these instances then, where there is care produced in a household for a household member in a target age group but the household roster lists no person in that age group, we assume that the error is one of coding and the care should actually be listed as care for a non-household member in that age group. The consumption allocation then follows the methods for care consumption by non-household members described above.

Data specifics: US

The individual-level time use data from the ATUS samples is merged with the household roster of persons, each with age and sex data. This creates where X_j is the amount of a particular type of direct care time produced by survey respondent j, $E_j(a, s)$ is the number of members age *a* and sex s in the household of the survey respondent where those household members are "enrolled" in the care target age group, i.e. they are in that age group. Age *a* is grouped in 2-year groups to reduce noise. The regression coefficients pick up the extent to which more care of a particular type is produced in households that have more members in a particular age/sex group. The positive $\alpha(a, s)$ coefficients that come out of the regression are then assigned to the relevant age and sex groups and used as weights to distribute a datafile that has a line for each household member, the ATUS respondents also having time use variables, the non-respondents have blanks for those variables. (In order for the time production estimates to be correct, it is important that the merge result with time-use non-respondents having blanks or missing data for time use variables and not zeros.

Data specifics: Korea

The KTUS has the necessary household roster information described above. It also has survey weights that allow the calculation to correctly balance weekend and weekdays.

2.1.3 PCW production

To create an analogous set of age/sex profiles to what was done for UCW in the market economy, we need a concept of what paid care work (PCW) is.

Overall, we want to define the paid part of the care economy as doing the same activities as the UCW activities, to be substitutes, to be more or less interchangeable. If you decided you no longer wanted to do a particular task as UCW you could pay someone else to do it instead, and vice versa. What sort of PCW would substitute for UCW? Whom would you call if you wanted to substitute a paid care provider for any of the care you usually do yourself on an unpaid basis? Whom would you no longer need to pay if you took over care work on an unpaid basis that you formerly paid someone else to do? These would be persons providing care for children, elders, the sick and disabled, like childcare workers, home health aides, and adult daycare workers. If you wanted to substitute a paid provider for volunteer work you had done, you might hire a general social worker. If you wanted to hire someone else to clean your house, you might hire a housekeeper or domestic help. These types of workers most directly substitute for UCW. However, this leaves a large group of direct care workers who might not be substitutes for UCW, but who by most definitions are care providers. These are the teachers, doctors, nurses, therapists, and other who are in care work but through their many years of training and high levels of regulation and credentialing would probably not be substitutable for an unpaid family caregiver in most circumstances. Given this conceptual complexity, the approach we will take is to include two different groups of paid care worker: one that is more professionalized, more credentialed, and likely not substitutable with unpaid care work and another that is similar to and substitutable with unpaid care work done by a typical family caregiver. We will refer to these two groups here as more- and less-credentialed.

We will keep these groups separate for the analysis so we can use the estimates to address different types of research and policy questions. For example, if our projections of the demand and supply of care provided by unpaid family caregivers shows that they will be in short supply in 20 years, a potential policy response to that would involve filling the gap with less-credentialed workers. Similarly, if our projections show that the demand for doctor's time looks like it will be greater than supply, we would need to focus on the future supply of doctors, knowing that we could not substitute that in the future with the time of unpaid family caregivers.

Certainly some of the care provided by credentialed professionals could be provided by non-professional or quasi-professional providers, and that may be one of the policy responses that policymakers will need to consider to satisfy care needs – stripping off as much care labor as possible from higher-paid more qualified professional caregivers and satisfying it less expensively with family caregivers or home health aides where possible (Osterman, 2017). While that is too complex an issue to consider in this work, if we keep those two different types of paid care as separate estimates, we can begin to document the scale of potential problems and extend the analysis to such a scenario in future work.

The types of workers mentioned so far – direct care providers, in-home domestic helpers, and more credentialed professionalized caregivers – are clearly in the paid care economy. There are many more workers, however, for whom the question is less clear. There are many more market-based substitutes for indirect UCW, the constant daily and intermittent

tasks of cooking, cleaning, shopping, laundry, household management and maintenance, than in-home domestic helpers.

One type of substitute involves using capital inputs instead. If I wanted to do less UCW for meal preparation I could buy a frozen entrée from the grocery store and use a microwave to do the rest. Similarly, I could buy a buy a robot vacuum to reduce my own UCW time spent cleaning. Are the workers involved in frozen entrée production or robot vacuum manufacture care workers? Existing occupational classifications would not consider them so but this tradeoff between unpaid care work and market-based capital inputs is an important dynamic. We will not consider it for our purposes here but it is certainly an issue for the overall conceptual framework of substituting UCW and PCW.

Another substitute other than servants are the paid workers in the service industry who provide indirect care services but are not considered domestic employees because, while they are contracted by the households to perform specific tasks, they are not in-home employees. These would be persons working for services providing cleaning, laundry, shopping, and other direct services. Unfortunately, occupational coding in most labor force data does not have sufficient detail to determine how many of the persons listed as "cleaners" would be in-home workers or someone cleaning industrial or commercial spaces. Similarly for many other types of workers, large groups of occupations combine both household service providers and commercial providers. For this reason, we will keep the PCW definition to the direct care providers and those whose occupations are covered under "domestic service" occupations.

Data specifics: US

The data for paid care work comes from the Current Population Survey's Annual Social and Economic Supplement (Flood et al., 2020). These were accessed through the IPUMS project. The item used to calculate hours worked by paid care workers is the usual hours worked weekly reported by the respondent. The occupational codes used to identify different types of paid care work are given in Table 3. The table is split into two parts, with Table 3a giving occupation codes for less-credentialed paid care workers and Table 3b giving occupation codes for more-credentialed paid care workers.

Table 3a. Activity codes in PCW estimates for the US from the CPS/ASEC accessed through IPUMS – Less Credentialed

PCW Activity	IPUMS-CPS Occupation Codes
Childcare Workers	4600 Child care workers
Care for Adults/Elderly/Sick	4610 Personal and home care aides 3600 Nursing, psychiatric, and home health aides 3610 Occupational therapist assistants and aides 3620 Physical therapist assistants and aides
General Social Work (similar to volunteering, less-credentialed)	2016 Social and human service assistants
Domestic help	4230 Maids and housekeeping cleaners

Table 3b. Activity codes in PCW estimates for the US from the CPS/ ASEC accessed through IPUMS – More Credentialed

PCW Activity	IPUMS-CPS Occupation Codes
Early Childhood Educators	2300 Preschool and kindergarten teachers
Teachers	2200 Postsecondary teachers 2310 Elementary and middle school teachers 2320 Secondary school teachers 2330 Special education teachers 2340 Other teachers and instructors
Medical Personnel	3000 Chiropractors 3010 Dentists 3020 Not used 3030 Dietitians and nutritionists 3040 Optometrists 3050 Pharmacists 3060 Physicians and surgeons 3110 Physician assistants 3120 Podiatrists 3140 Audiologists 3150 Occupational therapists 3160 Physical therapists 3200 Radiation therapists 3210 Recreational therapists 3220 Respiratory therapists 3230 Speech-language pathologists 3235 Exercise Physiologists 3245 Therapists, all other 3255 Registered nurses 3256 Nurse anesthetists 3257 Nurse midwives 3258 Nurse practitioners 3260 Health diagnosing and treating practitioners, all other 3300 Clinical laboratory technologists and technicians 3310 Dental hygienists 3320 Diagnostic related technologists and technicians 3400 Emergency medical technicians and paramedics 3420 Health practitioner support technologists and technicians 3500 Licensed practical and licensed vocational nurses 3510 Medical records and health information technicians 3520 Opticians, dispensing 3535 Miscellaneous health technologists and technicians 3540 Other healthcare practitioners and technical occupations

Credentialed Social Service Workers	2010 Social workers 2025 Miscellaneous community and social service specialists, including health educators and community health workers

Data Specifics: Korea

Data on Korean paid care workers come from the Korean Labor & Income Panel Study (KLIPS) samples from 2013-2015. The samples were pooled to increase the sample size, the years were chosen to correspond as closely in time to the time use survey from 2014. The occupation coding available in the KLIPS was less detailed than the US case, so larger groups of activities had to be combined together.

There are some respondents who answered work items such that their total work effort was unrealistically high. Some of these had to have been coding errors, such as the respondent reporting 240 hours per week worked which is more hours than exist in a week. Others may have been just exaggeration. To handle this, any respondent with over 80 hours per week of work was recoded to 80 hours. The occupation codes included in each PCW grouping are listed in Table 4, split into two parts for less- and more-credentialed as for the US.

Table 4a. Activity codes in PCW estimates for Korea from the KLIPS – Less Credentialed

PCW Activity	KLIPS Occupation Codes
All categories combined (Childcare Workers, Care for Adults/Elderly/Sick, General Social Work, Domestic Help)	421 Medical and Welfare Related Service Workers 951 Domestic Chores and Infant Rearing Helpers

Table 4b. Activity codes in PCW estimates for Korea from the KLIPS – More Credentialed

PCW Activity	IPUMS-CPS Occupation Codes
Early Childhood Educators	253 Kindergarten Teachers
Teachers	251 College Professors and Instructors 252 Teachers 254 Liberal Arts and Sciences, Technical and Arts Instructors 259 Other Teaching Professionals
Medical Personnel	241 Medical Diagnosis and treatment Professionals 242 Pharmacists and Oriental Pharmacists 243 Nurses 244 Dietitians 245 Physical Therapists and Medical Technologists 246 Health and Medical Related Workers
Credentialed Social Service Workers	247 Social Welfare Service Related Workers

2.1.4 PCW consumption

For the case of UCW consumption, household structure information was used to allocate the UCW production observed in the household to individuals. That is not possible in the case of PCW as the producers and consumers of the PCW reside in different households. Instead, we find proxy measures that indicate which age and sex groups consumed relatively more or less of the type of PCW in question. That proxy measure is then adjusted by a single multiplicative factor so that, in the aggregate, the total number of hours produced are accounted for as total hours consumed.

Data specifics: US

For less-credentialed unpaid care work, the proxy measure used comes from the Consumer Expenditure Survey (CEX). Using the CEX, and average annual household-level amount spent on less-credentialed care providers can be estimated. These types of care include childcare, tutors, home care aides, and in-house domestic servants. To move from a household-level amount spent to an individual-level indicator, we divide the amount spent by people in the household in the target age group, from the household roster, and assign that fraction to each person in the target age group. For example, if a household spent $1000 on babysitters in a year and there were two children under age 12 in the household, each would be assigned $500 as consumption. Ideally, there would be some indicator of which household member was consuming the PCW, but none was available for these types of PCW.

The imputation used is different than the regression method that was used to impute UCW consumption because of its greater simplicity. Also, in practice a regression method similar to that used for UCW gave similar results as the equal shares method, so the simpler approach was used. This should be a topic for further investigation in the future.
Once the household-level expenditure amounts are imputed to individuals, the age- and sex-specific averages are smoothed to create an age profile. This monetary-valued age profile is then transformed into a time-valued age profile by adjusting the aggregate to match the aggregate hours of care produced.

That adjustment is done by calculating one multiplicative adjustment factor that makes the consumption and production age profiles match in the aggregate. Specifically:

a: age a, ranges from 0 to ω (usually 85+ or 90+)
b: sex b
$N(a,b)$: population count, age *a*, from census or similar source
$x(a,b)$: per capita time production age schedule at age *a*, sex *b*
$y(a,b)$: per capita proxy consumption indicator age schedule at age *a*, sex b
$\theta = \frac{\sum_{a=0}^{\omega}\sum_{b=1}^{2} x(a,b)N(a,b)}{\sum_{a=0}^{\omega}\sum_{b=1}^{2} y(a,b)N(a,b)}$: adjustment factor

$\tilde{y}(a,b) = \theta y(a,b)$: per capita time consumption age schedule at age *a*, sex *b*

Note that this same adjustment procedure should be used after smoothing any pair of production-consumption profiles so that in the aggregate the flows are equal.

For more-credentialed PCW, the situation is more complex because so much of the pay for teachers, healthcare providers, and social work professionals is not part of a household budget and thus cannot be queried in a household consumer survey. For example, through public education, teacher salaries are paid for by taxpayers. Also, publicly-funded health insurance programs like Medicare pay for a large portion of health care, as do private insurers. For these types of care, then, we use the National Transfer Accounts (NTA) age profiles for health and education (United Nations, 2013) as proxy indicators of the relative age- and sex-specific levels of consumption. These age profiles use administrative data sources to estimate the total consumption of health and education by persons, including publicly and privately financed care whether it is out-of-pocket or not. The NTA age profiles are monetarily-valued profiles, but just as for the CEX data described, they can be adjusted to be time valued profiles by matching the aggregate amount of hours consumed with the aggregate number of hours produced.

To increase accuracy, the adjustment is done in parts. The amount of PCW time produced by teachers is adjusted to the education profile and by health care providers is adjusted to the health care profile. The hours produced by professional social workers is allocated per capital to the total population.

Data specifics: Korea

For the less-credentialed PCW, the investigation of Korean consumer expenditure data has not been carried out yet. So, the US age profile is used for Korea, but adjusted to the Korean aggregate number of hours produced.

For the Korean more-credentialed PCW, the Korean NTA age profiles for total health and education consumption are used. (Age profiles are available for download at www.ntaccounts.org.)

2.1.5 Other issues

Institutionalized populations will generally not appear in our survey datasets because they are based on household sampling frames and only pick up the household population. Our estimates from the time use surveys will then represent the non-institutionalized population. To get population representative data then, we must make an assumption about the production and consumption of care work by the institutionalized persons so the correct overall statistic can be calculated.

For unpaid care work, we assume that the institutionalized population produces and consumes no care. This is a reasonable assumption for nursing home patients as they are going to have poor health and be unlikely to be able to care for others. The other main types of institutionalized persons are inmates of correctional facilities, and residents of

college dorms and military barracks. While those persons may have families and friends, their residence in an institutional setting and not a family household means they have little opportunity to care for others.

For more credentialed paid care work, the issue with institutionalized persons is already figured into the NTA estimates that are used as a proxy of PCW consumption. in nursing homes are likely consuming even more paid care than those in the household population. For inmates and residents of military barracks or dorms, the situation is less clear.

2.2 Population projections

2.2.1 UN World Population Prospects, 2017

Full population projections by single years of age and time are available for all UN countries from the UN World Population Prospects database (https://population.un.org/wpp/). The projection period begins at 2015 and goes out to 2100. Thus, while we aim to project care to 2030, it is easy to extend that if we want to. These data are freely available online, easily accessible for both the US example case and the Korean case that will be used for the final projections.

One aspect of the UN projections will be particularly salient for the Korean case. The UN's projections program has many variants based on different scenarios of changes in the vital rates of fertility and mortality, and different migration scenarios. It is most common for researchers to use the "medium" variant. This variant uses projection techniques for fertility that include the assumption of very slow, long-term convergence to replacement fertility at the global level. What does this mean for the Korean estimates? That Korean fertility will "recover" from its current level substantially below replacement to a higher level: from an estimated total fertility rate (TFR) of 1.23 for the period 2010-2015, medium variant fertility rises to 1.46 for 2025-2030 and is 1.78 at the end of the total projection period in 2100.

This is not an unreasonable change in fertility, but it is also quite reasonable to think that Korean fertility will not rise at all. Fortunately, the UN produces its population projections with different fertility variants. To assess how robust the results are to future fertility scenario, these different variants can be used in the care support ratio calculations.

The only complexity with using the projections other than the medium is that the UN only releases the medium variant projection interpolated to single years of age and time. The other variants are only released in their original projection formats of 5x5 cells, i.e. five years of age every five years of time. For those other variants, the Beers interpolation method (see discussion in Shyrock & Siegel, 1980) is used to create the estimates by single years of age and time.

2.2.2 Statistics Korea population projections

Many countries produce their own population projections and note sometimes large differences between their own projections and the UN's. Statistics Korea (KOSTAT) has population projections starting in 2015 through 2065 (http://kostat.go.kr/portal/eng/pressReleases/8/8/index.board). These projections come in many diverse scenarios with different combinations of high, low, medium, or constant projections of fertility, mortality, and migration. Three variants will be evaluated here – combinations of vital rates that produced the highest and lowest population sizes over time, along with the medium variant which KOSTAT considers a "baseline" projection.

2.3 Care support ratios: evaluating mismatches

With the age- and sex-specific care consumption and production estimates and population projections, projecting forward in time is a straightforward manner of weighting the age- and sex-specific profiles by the changing populations to get projected total care demanded and supplied. This equates current consumption and production with demand and supply respectively. A straightforward calculation such as this allows us to gauge any potential mismatches between type of care demanded by future populations versus supplied by them.

These are not realistic scenarios, of course, because we know that somehow demand and supply must equal in the end – there is no way to "save up" someone's care time in one period in order to consume it at another time. This is obvious for direct care because it involves a face-to-face interaction. It is less obvious for indirect care through housework, as something like laundry can be produced in one period and the clean clothes are worn later. The distance in time between production and consumption of most indirect care is fairly close in time, even if it is not exactly synchronous. We make the assumption then that all types of care are consumed at the same moment as it is produced. Given this assumption, the actual consumption and production must always be equal and so the care support ratio must always be one, the market must always clear somehow. Calculating the care support ratio without modeling any equilibration mechanism allows us to evaluate how large any potential mismatches between care supply and demand might be. How equilibration might be achieved will be considered in future work. For the work considered here, it asks how much care would be supplied and demanded if the per capita patterns remained the same while only the population changed.

3. Assumptions

There are two main groups of assumptions in this work. There are assumptions involved in the consumption imputations. Then there are assumptions that are part of defining what is included or not in the definitions of UCW and PCW.

For the consumption imputations, we assume the equal consumption of indirect UCW by all household members and a data-driven allocation of direct UCW based on the associations among the age and sex of household members and the amounts of different types of care produced. For the equal allocation indirect UCW assumption, this could potentially flatten out the consumption curve more than if we had a more accurate way to

allocate the time. However, the equal consumption assumption imposes a larger theoretical stance about the consumption of indirect care, implying that while household members may spend different amounts of time in the household itself, they are all benefitting equally from the overall service of providing a well-run and functional household. The assumption treats housework as more or less a single service that everyone benefits from equally on an overall wellbeing level, even if household individuals might have different specific amounts of consumption of home-cooked meals, home-cleaned houses, home-laundered clothing, etc.

The other main sets of assumptions are in what is included or not included in the definition of care. Supervisory care, or care where someone is responsible for another person but not directly interacting with him or her is not included in this work. This is mainly for data reasons, not for theoretical ones. Ideally, we would be able to break out the direct UCW consumption and production into two groups, one where direct care provision is the main activity and another where it is supervisory only. This will be done for the US case, but not the Korean case because the survey instruments are so different. The effect of not including supervisory care will be to reduce the total amount of care in the estimates. The impacts on the care support ratios are less clear but will be discussed for the US case.

Finally, there is the assumption built into the scenario of holding the age profiles of care constant while changing the age and sex distribution of the population. As discussed previously, this is a completely unrealistic assumption by definition. It serves only as an indicator of how future consumption and production of care may have to change and where in the care economy will population change have a greater or lesser impact.

4. Future extensions of this work

Many potential extensions of this work have been mentioned previously, but to summarize, they consist of extensions to the age profiles themselves, to the age profiles and the population projections they are paired with, and finally to the nature of the scenarios considered.

To begin with changes to the age profiles, the issue of including supervisory care has already been discussed. While the US case will be discussed here, the Korean case can also be evaluated. Beyond the data supplied by the surveys themselves surrounding supervisory care, the issue could be assessed using very young children's need for constant supervision to impute supervisory care at least for this age group. In many US states and in many countries, laws mandate that a child younger than some cutoff age may not be left alone for more than a particular number of hours or even none at all for an infant. Assuming a total care need of 24 hours each day for an infant would allow for an indirect estimate of supervisory care.

Another type of age profile change that could be very relevant for understanding the care economy could be instances where an age profile can be subdivided into more sub-groups by some category and there are also population projections that incorporate changes in that category. Education is one example, used as a proxy of socioeconomic status (SES).

Separating out age profiles of care consumption and production education could reveal that persons of different SES status live in different care economies just as much as persons of different sex do. Those education-specific estimates could be combined with population projections by education[2] to create a projection of the care economy that incorporates changing education distributions. This could be particularly instructive for countries in which educational attainment has increased rapidly.

Some time use surveys include data on cognitive impairments. That could enable the estimation of care profiles specifically for persons with aging-related cognitive impairment. Using Global Burden of Disease data, population projections could be altered to include the population share with cognitive impairment and thus a projections scenario that incorporated changing prevalence of cognitive impairment in the population over time. Lastly, instead of future extensions of this work could consider equilibrating mechanisms between care supply and demand. There could be multiple models for this.

5. Conclusion

This document has detailed the procedures used to create age- and sex-specific per capita profiles of care production and consumption. These give a complete picture of the care economy across both paid and unpaid care sectors and can be estimated in any country with sufficient time use and other types of data. Further, it has described how those age profiles can be combined with population projections to give a simple way to evaluate whether the care economy as currently configured by age and sex will be sustainable in the face of population age distribution changes.

While the age profiles are innovative in that they combine care provided on both a paid and unpaid basis, the care support ratio projections do not incorporate any detailed equilibrating mechanisms that might predict how demand and supply will equalize if there is a shortage or surplus. While the realism suffers because of this, what is gained is simplicity and straightforwardness. This could make it a more useful tool in some respects for policymakers because it can be explained without recourse to a sophisticated behavioral model.

[2] https://iiasa.ac.at/web/home/research/researchPrograms/WorldPopulation/Research/ForecastsProjections/DemographyGlobalHumanCapital/EducationReconstructionProjections/education_reconstruction_and_projections.html

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