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Demand or supply for schooling in rural India?

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Abstract

Is the poor human capital investment of rural Indian families primarily a supply side or a demand side issue? Can time use data help analyze some of the hidden dimensions of development? We examine school attendance and total human capital investment time (time in school plus travel time plus in-home instructional time) using the Indian Time Use Survey of 1998-1999 and the 7th All India School Education Survey (AISES). Probit and sample selection bias regression estimates indicate that the influence of supply side factors (school quality and availability) is large relative to the impact of household characteristics (e.g. low income). We discuss the policy implications and illustrate the advantages of time use data in analysis of development.

JEL-Codes: I2, I24, I25, O15

Keywords: Schooling, human capital accumulation, rural India

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1 Introduction

The crucial role of human capital makes it all the more essential to pay attention to the close relation between sensible public action and economic progress, since public policy has much to contribute to the expansion of education and the promotion of skill formation. The role of widespread basic education in those countries with successful growth-mediated progress cannot be overemphasized "(Dreze and Sen, 2002)".

The value of education for development is increasingly recognised – both in the instrumental sense of enabling rapid growth in GDP and in the direct attainment of human self-consciousness and capability. India has been one of the fastest growing economies in the world today, but within India, and particularly within rural India, the distribution of educational opportunities and attainment is highly unequal. Schools in tents or outdoors, or with absentee teachers, coexist with schools whose teachers and resources are "world class" in quality and there is substantial variation across regions in the average level, and in the inequality in quality in local schools.[1]

Although no individual family can decide the nature of their local school system, those systems are (at least partly) the product of a collective choice, which acts as a constraint on individual choices. However, given the educational alternatives available to them in their local area, individual families may make very different decisions regarding their children's schooling – choices which will have enormous implications for their children's lives. This paper therefore asks: How much of the inequality in human capital investment in rural India can be explained by the supply side (i.e. variation in the availability and quality of locally available schooling), and how much can be attributed to the demand side (i.e. variation in the attributes and choices of students and households)?

As well as our direct interest in the substantive issue of school attendance, one of the purposes of this paper is methodological. We use two sources of data – the Indian Time Use Survey (ITUS) and the All India School Education Survey (AISES), and we match these two sources at the state level. The former provides data on time spent by children on human capital accumulation, and the latter provides indicators of school quality and availability. Our perspective is that some crucial aspects of the development process (e.g. human capital investment, social capital formation, environmental degradation)[2] largely occur outside the market economy and involve decisions about time allocation within households. In general, the data on market incomes and financial flows of households which economists usually analyze cannot reveal much about in-

[1] The literature on education in India is voluminous and we do not attempt to survey it here. Some important references are PROBE (1999); Dreze and Sen (2002) and the references therein.

[2] In a previous paper (Motiram and Osberg 2010a), we have used the ITUS to assess the relative importance of 'bridging' and 'bonding' social capital for access to drinking water. In future work, we plan to link ITUS data to geo-coded data on deforestation.

dividuals who have little or no money income or expenditure (e.g. children; many women; the very poor). However, every individual has 24 hours of time, every day, so the analysis of time use data can help us understand the lives of people who are often ignored in studies using conventional data. We hope to illustrate the potential advantages of time use data, particularly when merged with other data sources, in analyzing key aspects of the development process.

Analysis of time use data is particularly important in developing countries, where the proportion of poor tends to be high, the informal/unorganized sector employs a substantial proportion of people and the process of development is shifting activities and individuals from the informal economy of the household to the formal market sector. We argue that representative surveys of time use within households can help enormously in measuring the extent of the informal household economy and in understanding its transformation during the structural changes of the development process. We hope that this paper provides an impetus (at least to a certain extent) to the collection and analysis of time use data in developing countries.

Section 2 of the paper begins with a brief description of our data sources – the Indian Time Use Survey of 1998-1999 (ITUS) and the 7th All India School Education Survey of 2002 (AISES) – and presents an overview of school quality, attendance and time spent by children on human capital accumulation in India. Given that the ITUS is the only large representative time use survey available on India our paper is the first to investigate schooling and human capital accumulation using certain unique features of this data. Section 3 then presents probit estimates of the probability of school attendance while Section 4 uses sample selection bias regression techniques to examine the determinants of total human capital investment time (i.e. time spent in school plus travelling to and from school plus homework and in-home instructional time). Section 5 uses these estimates to compare the magnitude, and the inequality, of the human capital investment which is influenced by inequality in access to school facilities, relative to the impact of the social exclusion, low income or low education of Indian families. Section 6 concludes.

2 Description of the data

2.1 The Indian Time Use Survey

The Indian Time Use Survey (ITUS) was conducted by the Central Statistical Organization between June 1998 and July 1999 (for a detailed description of the methodology, see ITUS (1998)). The survey followed a two-stage stratified random sampling design (similar to the one used in the National Sample Surveys (NSS)) to collect information on 18,591 households (12,750 rural and 5,841 urban) with 77,593 persons (53,981 rural and 23,612 urban). To capture seasonal variations in the time use patterns, the survey was conducted in four rounds during the year. A team comprising of two people, one male and the other female, stayed in each village or urban block for nine days and compiled time diaries for normal, abnormal and weekly variant

days.[3] Respondent households were first visited to assess their weekly pattern of time use and then revisited to complete a full diary of activities concerning the previous day for all household members over six years of age. The data set contains an individual record of the day's activities of each adult and child over the age of six, a household-level record of household characteristics and an individual-level record of individual characteristics. Although in theory, normal, weekly variant and abnormal days could all be studied separately, since the proportions of abnormal and weekly variant days were found to be negligible,[4] we focus only on normal days in this paper.

The survey was conducted in six states: Haryana, Madhya Pradesh, Gujarat, Orissa, Tamil Nadu and Meghalaya representing northern, central, western, eastern, southern and north-eastern regions, respectively. Although a question can be raised about whether data from six states could fully capture the diversity of India, Hirway (2000:11) has argued that "cross-checking of the results has confirmed that the sample is fairly representative of the country."

One of the advantages of the ITUS is that time use data enables direct examination of whether an individual actually attends an educational institution or not- i.e. we can distinguish between attendance and mere enrolment (as inferred from the principal status of the individual as "student"). As well, we can examine the total time spent by each person in the household on human capital investment, adding up the time spent on attendance, on travel to school and on instruction within the home. The first two components are relevant only for children (who can actually attend school), whereas the third is relevant for both children (as receivers of instruction) and adults (i.e. parents or other elders in the household – as providers of instruction). In a previous paper (Motiram and Osberg, 2010b), we examined instruction within the home by parents. Here, we focus on children and the determinants of their attendance and human capital investment time.

As in our previous paper, we divide children into three age groups: 6-10, 11-14 and 15-18, roughly corresponding to primary, upper primary and secondary/higher-secondary educational levels, respectively.[5] Attendance rates fall off for both boys and girls as children age, reflecting both absenteeism and school dropout. At all ages, the attendance rates for boys are higher than the same for girls, a gender differential that is much greater (and increases more with age) in rural than in urban areas. For all age groups, both for boys and girls, the attendance for Scheduled Castes and Tribes (SC and ST), which are historically disadvantaged groups in the Indian

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3 An "abnormal" day is defined in the "Instruction Manual for Field Staff" ITUS (1998: 23) as "that day of the week when guest arrives, any member of the household suddenly falls sick, any festival occurs, etc.". The "weekly variant" is "determined according to the pattern of the major earners holiday. If the major earner does not holiday, then school children's holiday will be taken. If even this is not applicable, then day of weekly hat (bazaar) may be taken" (ITUS 1998: 23).

4 Hirway (2000:24) noted that: "On an average, of the total 7 days, 6.51 were normal, 0.44 weekly variant day and 0.05 was abnormal day… in rural areas people continue their normal activities on holidays also."

5 Primary stage is from class 1 to class 5, except in Gujarat and Meghalaya, where it is from class 1 to class 4; Upper primary stage is from class 6 to class 8, except in Gujarat (5 to 7), Meghalaya (5 to 7) and Orissa (6 to 7); Secondary and higher secondary stages are from class 9 to class 12 in Haryana, Madhya Pradesh and Tamil Nadu, and from class 8 to 12 in the other states. In all the states, higher secondary stage includes classes 11 and 12. See the AISES publications referred to below.

context, is lower than for others. Female literacy within the household also plays an important role – the presence of a literate female adult (e.g. mother, or an elder sister) at home is strongly positively correlated with attendance for all age groups for both boys and girls.

Our time use data enables us to calculate total human capital investment time for children - i.e. the sum of time spent in school, on travel to school and on work at home. Overall, given their lower rate of school attendance, girls spend on an average less time than boys on human capital investment at all ages – in total, and for each activity (attending school, homework or travelling to school). However, the difference between boys and girls is driven by participation – when we consider girls and boys who spend some time on an educational activity, on the average, they spend similar times at that activity, at all ages.

In analyzing time use data collected using the daily diary method one must recognize that the time devoted to particular activities may vary widely, for the same individual, from day to day and some activities are not necessarily observed every day. Hence, in order to understand the relative importance of particular activities, one must think in an expected value sense, and estimate the probability of episodic activities, and the expected value of time spent in each activity.

Fortunately, in doing such estimation, one is not necessarily limited to the variables in the original time use survey data set. The fact that the location of each respondent is known enables researchers to combine datasets using their geographic codes. In the merged data set, each individual respondent's record combines the time use survey's data on individual daily time use with variables, drawn from other data sources, measuring characteristics of the area in which they live. This enables the researcher to assess the influence that local area characteristics may have on the time use of respondents in that area. We employ this technique in this paper, as we have in others (e.g. in Motiram and Osberg (2010a), where the relevant characteristic of the local area is the availability of groundwater per capita at the district level).

2.2 The Seventh All India School Education Survey

Because the state that each respondent lives in is recorded in the ITUS micro-data, each respondent household in the ITUS can be exactly matched, using the geo-code for each state, to state level data from the Seventh All India School Education Survey (AISES). The AISES collected comprehensive data on a census basis on every facet of school education in India, as of September 30, 2002, e.g. the availability of schooling facilities in rural habitations, physical and educational facilities in schools, enrolment, teachers and their academic and professional qualifications etc. Some of this data, at the national and state level, is available in published reports, and we present some indicators for major states in Table 1.

We can observe from Table 1, which includes both public and private schools, that within India, there is remarkable variation across states in indicators of schooling. For example, in rural Meghalaya, only 77 percent of primary schools had a pucca or partly pucca building.

Table 1
Indicators of schooling in various states of India

	% Pucca/Partly Pucca				Pupil to teacher ratio				Schools
	Primary	Upper primary	Secon-dary	Higher secon-dary	Primary	Upper primary	Secon-dary	Higher secon-dary	Available
A.P.	85.4	92.3	96.1	95.4	33	31	31	28	4.886
Assam	80.7	75.5	83.9	95.6	31	16	18	20	5.521
Bihar	89.3	92.5	94.8	95.0	85	76	49	23	2.024
Chhattisgarh	92.6	92.1	93.7	97.6	43	39	30	32	6.018
Goa	98.8	100	99.5	100	17	13	23	21	7.643
Gujarat*	90.2	98.8	95.9	99.1	28	38	34	37	3.946
Haryana	98.7	99.5	99.5	99.3	42	26	28	30	2.964
H.P	89.5	78.1	92.3	95.6	22	15	25	24	9.692
J&K	80.0	91.2	93.8	98.6	20	20	20	23	5.562
Jharkhand	92.3	94.7	98.1	100	59	60	43	30	3.018
Karnataka	96.2	99.1	97.0	99.8	27	38	26	33	4.787
Kerala	99.2	99.4	98.8	99.6	28	28	27	29	1.889
M.P	91.2	87.7	91.4	96.0	39	31	27	28	5.179
Maharashtra	97.8	98.7	91.8	98.0	30	35	33	39	4.162
Meghalaya	77.0	82.9	89.3	97.3	21	16	16	23	10.495
Orissa	95.1	91.7	95.1	100	43	40	23	19	5.838
Punjab	99.5	93.4	99.1	99.9	39	17	23	25	3.840
Rajasthan	97.7	97.3	99.9	100	42	34	28	28	3.773
Tamil Nadu	96.4	98.8	95.5	98.2	35	42	37	37	4.272
U.P	97.7	96.7	99.0	99.5	61	37	44	55	2.846
Uttarakhand	97.2	93.9	97.4	99.9	29	19	23	27	8.381
West Bengal	91.7	89.2	98.3	99.9	55	52	61	58	2.824

Pucca and Partly Pucca is calculated based upon data in Tables 22-25 in AISES (2008a).
For the definition of pucca, see footnote 7.

Pupil to Teacher Ratio (PTR) for primary, upper primary and secondary levels is taken from AISES (2008b), Table 59 and for higher secondary level is taken from AISES (2008c), Table 56. PTR = Number of Enrolled Students/Number of Teachers.

Schools available=1000*Total Number of Schools/Estimated number of children aged 16-18 as on 30 Sep 2002. The number of schools is taken from AISES (2008a), Tables 22-25 and the number of children from AISES (2008d), Table 3. * States in bold are in the ones in the ITUS sample.
Source: The Indian Time Use Survey, own calculations.

On the contrary, in rural Punjab, 99.5 percent of primary schools were thus constructed. All (i.e. 100 percent) upper primary schools in rural Goa had a good (i.e. pucca or partly pucca[6]) building, whereas the corresponding figure for Assam was only 75.5 percent.

[6] A school is "pucca" if its walls are made of the following material: burnt bricks or stone or cement or concrete or timber; and its roof is made of tiles or GI (or metal or asbestos) sheets or concrete or bricks or stone or timber. A school is "partly pucca" if its walls are made of the same material as those used in the walls of a pucca school, but the roof is made of different material (e.g. grass, bamboo, thatch). The other kinds of

Similar variation existed at the secondary and higher secondary levels. The differences were more pronounced for Pupil-to-Teacher Ratios (PTRs). For rural primary and upper primary schools, the PTRs in Bihar were 85 and 76, respectively. The corresponding figures for Goa were only 17 and 13. The variation was comparable for secondary and higher secondary levels. Considerable variation also exists in the availability of schools.

There is considerable variation across the states in the ITUS sample (marked in bold in Table 1) which provides identifying variation for the analysis discussed below. As one would expect, states that are considered relatively underdeveloped are also the ones that are characterized by poor quality and availability of schools.

3 The probability of school attendance

Since the primary way in which children acquire human capital is by school attendance, we want to understand the factors influencing the likelihood that they will (or will not) attend school – which can be categorized as affecting either the demand for schooling or the supply of schooling.

Exploring the demand side first, individual and family characteristics influence the perceived net future returns (monetary and non-monetary) that families expect from schooling, which differ due to different families having different "tastes" for schooling, or differing opportunity costs of schooling or differing ability to finance schooling. Both in developing countries and in affluent OECD nations, the occupational and educational background of parents has long been recognized as the crucial determinant of children's educational attainment and the intergenerational transmission of socio-economic status.[7] Additionally, in the Indian context, caste is an important factor. Scheduled Caste or Tribe status could result in exclusion or discrimination in schooling facilities, or in the labour market.

On the supply side of schooling, the availability and quality of schools affects the expected net returns from schooling. As Hanushek et al. (2006) conclude: "a student is much less likely to remain in school if attending a low quality school rather than a high quality school." For most families, the availability and quality of schools in their local area is an exogenous constraint

schools are: kuchcha (walls and roof made of other material, e.g. unburnt bricks, bamboo, mud, grass); tent; open space (i.e. no building). See AISES (2007d, pp. 224-225).

[7] See, for example, Dreze and Kingdon (2001), Jantti et al. (2006), Corak (2004, 2006), Blanden et al. (2007), and Wilson et al. (2007).

determining the family's schooling options.[8] In this paper, we therefore use state level AISES data on the availability and quality of schools, as explanatory variables.[9]

Within affluent OECD countries, all of which have well-developed systems of public education which provide universally available access to schooling of reasonably high quality, one could perhaps neglect the supply side – but India's context is different (as we saw in section 2.1). Although there is much discussion of inequalities of educational opportunity in the school system within, for example, the USA, the disparities among US states in availability, physical facilities and teacher student ratios are far smaller than among Indian states.

We use two indicators of quality, viz. the percentage of schools with good physical construction – pucca or partly pucca building – and the Pupil-Teacher Ratio, (which is more of a measure of teacher availability). Although teacher absenteeism, or performance on standardized test scores etc., would perhaps be better measures of actual school quality, that data is not available for us (or, for that matter, to parents) to use – and is arguably of less relevance to the decision-making of Indian parents than the characteristics of the school which they can actually directly observe themselves.

As mentioned earlier, this paper addresses the relative importance, in the context of rural India, of individual and household level characteristics which influence the demand for education, compared to the quality and availability of educational supply. Equation 1 summarizes the discussion.

$$\Pr\left(S_i > 0\right) = f\left(X_i, F_i, Q_i\right). \tag{1}$$

S_i is the time spent by child i in school (including commuting time and homework). The probability that the child attends school ($S_i>0$) is determined by: X_i - a vector of characteristics of child i (e.g. age, gender); F_i - a vector of characteristics of the family that the child i belongs to (e.g. caste, education level of the household head); and Q_i - a vector of characteristics describing the availability and quality of schools in the state that the child i belongs to. We use a probit regression to estimate equation (1), considering separately, rural boys and girls, aged 6 to 10, 11 to 14 and 15 to 18.[10] We estimate these regressions separately because the assumption that the same model fits all these different age and gender groups may be unsustainable.

AISES data is used to construct for each state, variables indicative of the availability (number of schools per-capita[11]) and quality of the school system – the percentage of schools with good

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8 Writing in the context of the variation in supply of local public good in the suburbs of US cities, Tiebout (1956) argued that individuals could move between jurisdictions to satisfy their preferences for local public goods supply. If this model were applicable to the Indian context, local school system characteristics would be endogenous to local household preferences: but the nature of schooling in India and the more limited migration of Indian households for education (NSSO 2000) makes this a poor assumption, in this context.

9 In doing so, we recognise that within-state variability in local school quality can create attenuation bias, biasing downward the size and statistical significance of any estimated coefficient.

10 Given that there is controversy and debate regarding whether weights should be used in regressions (see Deaton 1997, Section 2.1), we present results with unweighted regressions.

11 We compute the per-capita measures by dividing the total number of schools (Primary to Higher Secondary) by the number of "potential" students, i.e. children in the age group 6-18 (Table 2, AISES (2007a)).

infrastructure (pucca or partly pucca buildings) and the Pupil to Teacher Ratio (PTR). In each state, household micro-data from the ITUS is matched, using the geo-codes on each file, to the corresponding state-level indicators of availability and quality from the AISES.

Table 2 presents descriptive statistics for the sample[12]. In addition to the above independent variables, two other variables (number of females aged 15 or above in the household, and time spent by the household in fetching water) are used in the regression on human capital accumulation time (discussed below). We also present the descriptive statistics for these variables, for the total human capital allocation time, and its three components (school time, home work time and travel time).

Because we run separate regressions for boys and girls and for each age group, we report separately the descriptive statistics for each sample – but we would not generally expect to observe big differences between columns[13]. In our data, it is notable that the majority (roughly 57%) of children live in households which have a self-employed head, with less than a primary education and have no literate adult female in the household. Just under 40% of the households are landless and about a third are Scheduled Caste or Scheduled Tribe (SC or ST). Female headed households are not an insignificant fraction – even in rural India, about 8% of children live in such households. Although we present here the time spent on water collection as an average over all households, arguably that understates the time burden on those households who have to collect water (see Motiram and Osberg 2010a for more discussion).

As we can observe from table 2, sample sizes for girls are lower than the same for boys due to an adverse sex-ratio prevailing in India. As mentioned above, attendance rates for boys are higher than the same for girls for all age cohorts. Similarly, the total time spent on human capital accumulation (and its three components) for boys is higher than the same for girls – this is largely a reflection of differences in attendance rates.[14] Table 2 shows time spent on education averaged over all children of the same age and gender, including those who do not attend school. The differences between boys and girls, and the drop-off in school attendance with age explain the declining average time investment in human capital as children age (for a fuller discussion see Motiram and Osberg 2010b). None the less, Table 2 also reveals the importance of homework as a proportion of total human capital investment time.

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[12] In the interests of space, given that we have six regressions, we have presented only the mean and standard deviation. The maximum and minimum values are available upon request. Also note that some dependent variables are dummies and therefore have a minimum value of zero and maximum value of 1.

[13] Households containing older children have somewhat higher average per capita monthly expenditures, no doubt due to the earnings of teenagers, but the difference is not statistically significant.

[14] Since only those children attending school would spend time accumulating human capital.

Table 2
Descriptive statistics, individual and household variables

	6-10		11-14		15-18	
	Boys	Girls	Boys	Girls	Boys	Girls
Age in years	8.426	8.411	12.517	12.561	16.481	16.577
	(1.278)	(1.313)	(1.046)	(1.051)	(1.199)	(1.185)
Monthly per-capita	408.086	388.410	430.680	422.432	462.043	449.474
Expenditure (in Rs.)	200.186	181.911	225.816	201.044	233.659	237.619
			Fraction			
Currently married[a]					0.019	0.141
					(0.136)	(0.348)
Self employed[a]	0.563	0.559	0.563	0.568	0.579	0.585
	(0.496)	(0.497)	(0.496)	(0.496)	(0.494)	(0.493)
Other employed[a]	0.099	0.098	0.104	0.109	0.102	0.098
	(0.298)	(0.297)	(0.305)	(0.312)	(0.303)	(0.298)
Landless[a]	0.395	0.392	0.383	0.379	0.374	0.370
	(0.489)	(0.488)	(0.486)	(0.485)	(0.484)	(0.483)
SC or ST[a]	0.375	0.408	0.331	0.322	0.329	0.321
	(0.484)	(0.492)	(0.471)	(0.467)	(0.470)	(0.467)
Female headed[a]	0.071	0.072	0.071	0.086	0.090	0.106
	(.256)	(0.259)	(0.257)	(0.281)	(0.287)	(0.307)
No literate female	0.588	0.580	0.520	0.480		
Adult (older than 15)[a]	(0.492)	(0.494)	(0.500)	(0.500)		
No literate female					0.583	0.556
Adult (older than 18)[a]					(0.493)	(0.497)
			Education of household head			
Below primary[b]	0.556	0.581	0.597	0.656	0.583	0.583
	(0.497)	(0.493)	(0.491)	(0.475)	(0.493)	(0.493)
Primary[b]	.401	0.420	0.451	0.476	0.434	0.437
	(0.490)	(0.494)	(0.498)	(0.500)	(0.496)	(0.496)
Middle[b]	0.256	0.256	0.292	0.300	0.268	0.264
	(0.437)	(0.436)	(0.455)	(0.458)	(0.443)	(0.441)
Secondary[b]	0.129	0.131	0.138	0.154	0.138	0.137
	(0.335)	(0.337)	(0.345)	(0.361)	(0.345)	(0.344)
H. Secondary[b]	0.055	0.052	0.060	0.060	0.056	0.059
	(0.228)	(0.223)	(0.237)	(0.237)	(0.230)	(0.236)
Grad or above[b]	0.020	0.019	0.022	0.026	0.026	0.020
	(0.141)	(0.136)	(0.148)	(0.160)	(0.158)	(0.140)

Table 2 Cont.
Descriptive statistics, individual and household variables

	6-10		11-14		15-18	
	Boys	Girls	Boys	Girls	Boys	Girls
Winter (Season dummy[c])	0.192	0.190	0.174	0.190	0.179	0.176
	(0.394)	(0.392)	(0.379)	(0.392)	(0.384)	(0.381)
Summer (Season dummy[c])	0.265	0.248	0.244	0.242	0.257	0.265
	(0.442)	(0.432)	(0.430)	(0.428)	(0.437)	(0.442)
Post-monsoon	0.267	0.252	0.257	0.254	0.249	0.247
	(0.442)	(0.434)	(0.437)	(0.436)	(0.432)	(0.431)
Attending school[a]	0.700	0.658	0.661	0.556	0.327	0.208
	(0.458)	(0.474)	(0.474)	(0.497)	(0.469)	(0.406)
Number of females	1.325	1.341	1.432	1.457	1.468	2.214
Above 15 years	(0.701)	(0.712)	(0.785)	(0.797)	(0.771)	(0.936)
Time spent by HH on	8.908	9.240	11.618	13.623	13.102	15.279
Water collection[d]	(26.412)	(28.276)	(31.276)	(36.236)	(32.836)	(37.729)
In-class time (S_i)[d]	217.524	204.634	212.716	179.446	105.198	68.115
	(156.546)	(159.211)	(164.610)	(170.724)	(159.090)	(140.080)
Homework time (H_i)[d]	79.066	73.627	95.144	80.194	61.782	37.958
	(94.322)	(90.313)	(105.108)	(103.304)	(108.472)	(89.896)
Travel time (T_i)[d]	27.326	25.292	31.686	25.055	20.784	12.025
	(31.024)	(35.416)	(37.981)	(35.181)	(39.602)	(29.144)
Human capital time [d]	310.282	291.910	325.511	272.070	172.996	107.610
	(222.182)	(227.984)	(249.023)	(256.955)	(256.695)	(216.635)
Observations	2409	2002	1839	1678	2062	1658

Note. The values reported are means. The values in parentheses () are standard deviations.
Both are for the sample (i.e. not using the sampling weights).

(a). Dummy variables, 1=Yes and 0=No. For marital status, there are four possibilities: (i) never married, (ii) currently married, (iii) widowed, and (iv) divorced or separated. Only a few (7) among those aged 15-18 fall into this category, and these are all girls.

(b). These dummies refer to the education levels of the Household Head.

(c). =1 if a child is surveyed in a particular season, and 0 if not. For a description of these seasons, see p. 10.

(d). All times in minutes per normal day.

Source: The Indian Time Use Survey, own calculations.

Table 3 presents the descriptive statistics for the school quality variables. Note that there are six states in the sample and these statistics are computed based upon six observations, one for each state, for each variable. As we noted above, there is considerable variation across states in terms of their quality indicators.

Table 4 presents the estimates from the probit regression. A consistent finding in Table 4, with only a few exceptions, is the statistically significant (at 1%) positive correlation between school attendance and our indicator of high quality school construction. Similarly, with a few exceptions, as expected, the coefficient on PTR is large, negative and statistically significant (at 1% or 5%). Except for the highest age group (15-18) and boys aged 11-14, the coefficient for the availability of schools is consistently positive and statistically significant (at 1%).

In Table 4, a [0,1] dummy variable identifies households in which there is no literate adult female (e.g. mother or elder sister). For both boys and girls, for all age groups, this variable comes through very strongly – statistically significant (at 1% or 5%) and negatively correlated with school attendance.

Table 3
Descriptive statistics, School quality variables

School quality variables	
% Pucca or partly pucca schools (primary)	0.915
	(0.078)
% Pucca or partly pucca schools (upper primary)	0.932
	(0.069)
% Pucca or partly pucca schools (secondary and h. secondary)[a]	0.952
	(0.032)
PTR (primary)	34.667
	(8.641)
PTR (upper primary)	32.167
	(9.928)
PTR (secondary and higher secondary)[b]	28.189
	(7.456)
Number of schools per-capita	5.449
	(2.665)

Note: (a). See notes to table 1.

(b). The combined (Secondary and H. Secondary) value is obtained in the following manner: Number of Pucca or Partly Pucca Secondary and Higher Secondary Schools/Total Number of Secondary and Higher Secondary Schools.

The combined PTR (Secondary and H. Secondary) is obtained in the following manner: (PTR (Secondary)*Number of Secondary Teachers+PTR (H. Secondary)*Number of H. Secondary Teachers)/The number of Secondary and Higher Secondary teachers. The number of Secondary and Higher Secondary teachers are taken from AISES (2008b) and AISES (2008c), respectively.

Source: The Indian Time Use Survey, own calculations.

The educational background of the head of each household is measured by a series of dummy variables indicating the marginal influence of schooling attainment, relative to lower levels of school attainment. The base case is a household head with no formal education, so a [0,1] dummy variable indicates whether the head has some primary school, another [0,1] dummy variable indicates whether the head has finished primary school, and another [0,1] dummy variable indicates whether the head has finished middle school etc. Anyone who has finished primary school will necessarily be coded [1] for both "some primary" and "finished primary", while a middle school graduate will be coded [1] for each of "some primary", "finished primary" and "finished middle school" – so the cumulative influence of education is the sum of coefficients at earlier levels of education.

Table 4
Probit model for the determinants of attendance
(dependent variable: 1 if child is attending school and 0 if not)

	6-10		11-14		15-18	
	Boys	Girls	Boys	Girls	Boys	Girls
Age in years	-0.063***	-0.059**	-0.119***	-0.180***	-0.298***	-0.395***
	(0.023)	(0.024)	(0.031)	(0.032)	(0.027)	(0.038)
Currently married					-0.630*	-0.391*
					(0.357)	(0.210)
Self employed	-0.074	-0.129*	-0.136	-0.029	0.107	-0.032
	(0.073)	(0.078)	(0.083)	(0.086)	(0.083)	(0.110)
Other employed	0.217*	0.142	0.512***	0.182	0.207*	0.016
	(0.121)	(0.130)	(0.139)	(0.127)	(0.118)	(0.149)
Landless	-0.081	-0.054	-0.132*	-0.050	0.062	0.051
	(0.069)	(0.074)	(0.079)	(0.082)	(0.077)	(0.099)
Monthly per-capita	-0.009	0.042**	-0.023	0.045**	0.052***	0.077***
Expenditure (100s of Rs.)	(0.017)	(0.021)	(0.016)	(0.019)	(0.014)	(0.017)
SC or ST	-0.193***	-0.195***	-0.045	-0.112	-0.028	-0.031
	(0.064)	(0.066)	(0.073)	(0.076)	(0.072)	(0.098)
Female headed	-0.127	-0.036	0.020	-0.070	-0.013	-0.004
	(0.115)	(0.127)	(0.130)	(0.121)	(0.112)	(0.132)
No literate female	-0.172**	-0.493***	-0.292***	-0.497***		
Adult (older than 15)	(0.073)	(0.075)	(0.075)	(0.076)		
No literate female					-0.288***	-0.517***
Adult (older than 18)					(0.074)	(0.093)
Below primary	0.343***	0.229**	0.306***	0.255***	0.147	0.025
	(0.089)	(0.094)	(0.099)	(0.098)	(0.098)	(0.133)
Primary	-0.046	0.057	-0.047	0.221**	0.148	0.215
	(0.110)	(0.110)	(0.114)	(0.109)	(0.107)	(0.141)
Middle	-0.072	-0.005	0.289**	0.060	0.203*	0.386***
	(0.116)	(0.123)	(0.120)	(0.118)	(0.110)	(0.135)
Secondary	0.212	0.201	0.104	0.109	-0.007	-0.126
	(0.147)	(0.157)	(0.159)	(0.145)	(0.130)	(0.159)
H. secondary	-0.256	0.001	-0.116	0.077	0.196	0.256
	(0.205)	(0.231)	(0.229)	(0.229)	(0.198)	(0.211)
Grad or above	0.155	-0.136	0.504	0.181	0.056	-0.088
	(0.278)	(0.324)	(0.347)	(0.329)	(0.253)	(0.290)
% Pucca or partly	12.342***	9.198***				
Pucca schools (primary)	(1.689)	(1.783)				
% Pucca or partly			3.287***	3.866***		
Pucca schools (upper pr.)			(1.097)	(1.120)		

Table 4 Cont.
Probit model for the determinants of attendance,
(dependent variable: 1 if child is attending school and 0 if not)

	6-10		11-14		15-18	
	Boys	Girls	Boys	Girls	Boys	Girls
% Pucca or partly					5.838**	0.107
Pucca schools (secondary and h. secondary)					-2.540	-3.712
PTR (Primary)	-0.050***	-0.049***				
	(0.009)	(0.010)				
PTR (Upper Primary)			-0.007	-0.015**		
			(0.006)	(0.007)		
PTR (Secondary and Higher Secondary)					-0.030***	-0.014
					(0.008)	(0.010)
No. of Schools	0.147***	0.150***	0.033	0.151***	0.029	0.055
Per-capita	(0.039)	(0.041)	(0.042)	(0.041)	(0.048)	(0.065)
Winter (Saison dummy)	0.611***	0.245***	0.386***	0.209**	0.040	0.332***
	(0.090)	(0.093)	(0.099)	(0.097)	(0.090)	(0.115)
Summer (Saison dummy)	-0.565***	-0.750***	-0.500***	-0.626***	-0.499***	-0.329***
	(0.074)	(0.082)	(0.083)	(0.089)	(0.086)	(0.111)
Post-Monsoon	0.485***	0.106	0.302***	0.065	0.109	0.136
	(0.081)	(0.085)	(0.086)	(0.089)	(0.080)	(0.106)
Constant	-9.185***	-6.284***	-0.963	-1.516	-0.697	5.336
	(1.495)	(1.589)	(1.159)	(1.176)	(2.691)	(3.908)
Observations	2409	2002	1839	1678	2062	1658

*** 1%, ** 5%, * 10%, The values in parentheses () are standard errors.
Note. For a description of these variables, see notes to tables 2 and 3.
Source: The Indian Time Use Survey, own calculations.

It is evident that for both boys and girls aged 6 to 10, a crucial issue in attendance at primary school is whether or not one's parents have *any* education.[15] Compared to the base case of no formal education, the dummy variable for "some primary" is a strongly significant (statistically significant at 1% or 5%) determinant of school attendance for both boys and girls.

The statistical insignificance of higher levels of school attainment indicates that among parents with higher schooling levels, there is no particular difference in their desire for primary school attendance by their children. However, for children in higher age groups, higher educational levels play a role, e.g. for girls aged 11-14, the coefficient on primary education is statistically

[15] About 87% of children aged 6 to 18 are unmarried children of the household head. So, we use term "parent" for ease of exposition.

significant (at 5%) and positively associated with attendance. Broadly speaking, we can interpret these findings as indicative of an escalating intergenerational norm within families for more education.

Current household income is approximated in the ITUS by aggregate monthly expenditure per capita. The respondents to the ITUS were asked a single summary question about total average monthly expenditures by the household rather than the series of questions on categories of consumption which a household expenditure survey would use, to add up total consumption. We are therefore cautious about possible measurement error in this variable[16] – particularly since it is unlikely to include self-production of food and fuel. Nevertheless, income is uncorrelated with the school attendance of boys aged 6 to 10 and 10 to 14 (columns 1 and 3). However, the positive and statistically significant coefficients in columns 2 and 4 (at 5%) indicate that family income matters for similarly aged girls – i.e. there is some evidence of interaction between economic disadvantage and gender bias in early schooling. More generally – over and above the direct influence of parental education – the statistically significant (at 1%) positive correlation of household income and school attendance for both boys and girls ages 15 to 18 is an important indicator of inequality of opportunity.

Columns 1 and 2 indicate that the social disadvantage of membership in a Scheduled Caste or Tribe[17] is directly correlated with lower early school attendance, in addition to the influence of household income or parental education, but columns 3 to 6 show no statistically significant correlation with later attendance. In the highest age group (15 to 18), since it is possible that a child could be married (although the legal age for marriage is 18 for girls, and 21 for boys), we controlled for marital status. As expected, a child is less likely to attend if he/she is currently married.[18] We controlled for the occupational status of the household by taking a labourer household as the base with the other categories being self-employed (in agriculture or non-agriculture) and others. As can be seen from table 2, the results are not consistent across the age and gender groups, although there is some evidence that attendance varies across occupational categories. Although we include a dummy variable for female household head status and another for landlessness, neither is statistically significant, once we have controlled for income and education.

The ITUS was conducted in different months of the year and the date of the normal day was recorded for each respondent. Since Indian rural economy and society (like in other developing countries) is dominated by agriculture, we used seasonal dummies. We considered the following seasons, based upon the climate profile for India (IMD 2011): winter (January, February,

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16 Our caution is also partly due to the relatively small reported differentials in monthly expenditure for households with large differentials in land owned. The correlation between monthly per-capita expenditure and land ownership is also very low (0.16).

17 There is extensive literature on the Indian caste system and its implications for development. See Chatterjee (1993), Gupta (1993) and Dreze and Sen (2002).

18 ITUS divides individuals into four categories based upon marital status – (i) never married, (ii) currently married, (iii) widowed and (iv) divorced/separated. As is expected (since we are dealing with children), there are very few (7) individuals in the last two categories, and that too only among girls.

December (for Haryana and Gujarat)), summer (March, April, May), South West monsoon (June to September) and post-monsoon/North East monsoon (October, November, December (for states other than Haryana and Gujarat)). The base category we used is the South West monsoon. We find some evidence that during the monsoon (when a considerable amount of agricultural work is required), children are not in school – probably pulled out of school to work. The coefficient on the winter and post-monsoon dummies are positive and statistically significant for some age and gender groups. The coefficient on the dummy for summer is negative since schools are generally closed during the summer.

4 Time invested in education

Time use data enables a much better picture of human capital investment, since the total time invested in education by each child *i* (HK_i) is the sum of the time he/she spends in class (S_i) plus the time he/she spends doing homework (H_i) plus travel time (T_i), to and from school – as equation (2) summarizes.

$$HK_i = S_i + H_i + T_i \,. \tag{2}$$

Generally speaking, it is not possible to attend school for ½ or ¾ hours each day, which implies that the normal school day is a "lump" of time. On any given day, some of the children who would normally be in school will be absent, due to competing work responsibilities, or because they want to skip school. We only observe S_i for those children who actually attend school on the day surveyed by ITUS, so the estimation of expected HK_i is a classic "sample selection bias" problem in the sense of Heckman (1979). Hence, we include as an explanatory variable, the Inverse Mills Ratio (IMR) (denoted as λ_i) derived from the probit estimation of equation (1) above. We also include W_i – time allocated to other activities within the household, which may influence the time allocated to human capital accumulation. A general form of the equation can then be summarized as:

$$E\left(HK_i\right) = g\left(X_i, F_i, Q_i, W_i, \lambda_i\right). \tag{3}$$

i is the index for the child. X_i, F_i, Q_i as defined earlier (in (1)), are the vectors of child characteristics, family characteristics, and availability and quality of schooling, respectively. In other work[19], we have found that 16% of households in rural India have to spend time collecting water (a highly gendered task) for daily use. For the development process, an important implication of carrying water is its possible impact on human capital acquisition – specifically, on the time that children will spend in school, travelling or doing homework. Rural women who spend an average of 47 minutes per normal day carrying water do not have that time available to spend attending to their children – unless perhaps they can delegate the task of fetching water to their teenage daughters, which may be part of the reason their daughters withdraw from school.

[19] Motiram and Osberg (2010a) presented data on the gendered burden of water carrying, and explored the determinants of piped water availability.

Even if children are not asked to carry water themselves, the fact that someone (usually the mother) has to spend time on this task means that children may be asked to perform other household chores – which implies that total household time spent in water collection may affect school attendance and human capital investment[20]. Given that Table 4 shows the importance of adult female education for the school attendance of their children, this impact of water collection time on female investment in education can be expected to have implications over many future generations. We also include the number of women in the household aged 15 or higher since the task of collecting water can be spread over several members.

From the perspective of costs to the household, all the three component activities (i.e. school, home work and travel) are part of the cost of human capital investment, since they all take away from competing uses of time. However, viewed from the perspective of returns to investment, one could consider school and home work time as "productive" and travel as "unproductive." It is not obvious, a priori, if the time spent on homework complements or substitutes for school time – homework could either increase or decrease with quality of the school that the child attends.

In table 5, we report estimates of equation (2) for boys and girls for three age groups (6-10, 11-14 and 15-18). We ran both Ordinary Least Squares (OLS) and "Heckit" estimates (i.e. OLS estimates with the Inverse Mills Ratio (IMR) added as an explanatory variable). As is standard, where the IMR is statistically significant (at 5%), we prefer, and therefore report the Heckit estimates. Where this is not the case (i.e. not statistically significant), we report the OLS estimates. There is evidence of sample selection only at the youngest age group, for both boys and girls.

Except for boys aged 11-14, in all age groups, and for both genders, the amount of time a household has to spend collecting water for daily use is negatively correlated with the amount of time spent on the education of children. Public policy on water delivery therefore affects both current and future well-being. The availability of tap water matters directly for the well-being of the women who would otherwise have to perform the daily drudgery of carrying water and indirectly for the future earnings and well-being of the children whose investment in education is lessened.

Public policy on the availability and quality of schooling also has a clear impact. For both boys and girls, the quality of school buildings and the availability of schools are strongly statistically significant and positively associated with the human capital investment time of children.

Another lesson from table 5 is the non-homogeneity of impacts by level of education. For example, whether a child comes from a Scheduled Caste or Scheduled Tribe family is not statistically significant for time spent on early education (ages 6 to 10), but is statistically significant and negatively associated with time spent in later years: 11 to 18 (for both boys and girls).

[20] Note that water-carrying time is measured at the household level, so it could all be done by adults - there is no necessary subtraction from the time available for school of any particular child.

Table 5
Determinants of human capital accumulation time of children
(dependent variable: Human capital accumulation time in mins/normal day)

	6-10		11 -14		15-18	
	Boys	Girls	Boys	Girls	Boys	Girls
Age (in years)	14.461 ***	13.419 ***	9.426 ***	9.903 ***	3.114	-5.868
	(2.275)	(2.490)	(2.778)	(3.212)	(3.867)	(6.531)
Currently married					21.171	-17.418
					(78.119)	(48.804)
Self employed	6.876	27.279 ***	-11.478	1.770	-21.963 *	8.858
	(6.239)	(7.397)	(7.862)	(9.079)	(11.785)	(19.337)
Other employed	-3.151	15.613	12.030	31.215 ***	-2.048	2.429
	(9.539)	(10.470)	(10.039)	(11.834)	(15.157)	(22.946)
Landless	6.896	8.419	-17.812 **	-6.675	-18.083 *	8.397
	(5.808)	(6.368)	(7.264)	(8.284)	(10.428)	(16.335)
Monthly per-capita	-2.538 *	-6.645 ***	-4.997 ***	-9.035 ***	0.185	-3.949
Expenditure (100s of Rs.)	(1.311)	(1.821)	(1.409)	(1.774)	(1.777)	(2.667)
SC or ST	-6.143	1.425	-17.219 **	-30.730 ***	-35.790 ***	-37.299 **
	(6.718)	(7.915)	(6.801)	(8.194)	(10.380)	(16.478)
Female headed	12.456	13.440	9.317	-27.066 **	-18.688	-9.735
	(10.053)	(10.626)	(11.723)	(12.855)	(15.912)	(21.033)
No literate female	1.352	30.849 **	-5.022	-8.788		
Adult (older than 15)	(6.817)	(13.640)	(7.148)	(8.644)		
No literate female					8.251	-23.298
Adult (older than 18)					(10.567)	(16.650)
Below primary	-9.621	-12.565	-4.223	3.519	-0.088	16.427
	(10.137)	(10.680)	(9.450)	(11.263)	(14.566)	(23.631)
Primary	6.045	-24.108 ***	0.630	-13.230	-38.828 **	-27.591
	(8.293)	(9.085)	(10.450)	(11.280)	(15.047)	(23.283)
Middle	0.497	4.807	14.115	19.773 *	28.686 **	16.251
	(8.714)	(9.460)	(9.947)	(11.084)	(14.310)	(20.235)
Secondary	-15.298	-9.333	-9.333	-8.733	8.692	-37.369 *
	(10.653)	(11.812)	(11.455)	(12.691)	(16.194)	(21.567)
H. secondary	31.055 **	27.436 *	15.407	18.890	2.299	40.949
	(15.262)	(15.987)	(16.497)	(18.663)	(22.380)	(27.166)
Grad or above	-28.560	-9.919	15.982	-5.074	-36.120	-5.338
	(19.953)	(22.059)	(21.492)	(23.641)	(27.199)	(35.821)
% Pucca or partly	1272.239 ***	1291.079 ***				
Pucca schools (Primary)	(272.504)	(262.559)				
% Pucca or partly			558.231 ***	463.390 ***		

Table 5 Cont.
Determinants of human capital accumulation time of children
(dependent variable: Human capital accumulation time in mins/normal day)

	6-10		11-14		15-18	
	Boys	Girls	Boys	Girls	Boys	Girls
Pucca schools (Upper primary)			(112.404)	(122.217)		
% Pucca or partly					2613.852 ***	2258.224 ***
Pucca schools (Secondary and h. secondary)					(359.884)	(601.186)
PTR (Primary)	-2.813 **	-2.395 *				
	(1.201)	(1.440)				
PTR (Upper primary)			2.792 ***	3.199 ***		
			(0.609)	(0.694)		
PTR (Secondary)					2.168 **	2.042
PTR (Higher secondary)					(1.093)	(1.649)
No. of schools	16.137 ***	17.507 ***	21.029 ***	15.431 ***	38.717 ***	29.508 ***
Per-capita	(4.144)	(4.994)	(4.230)	(4.035)	(6.575)	(10.301)
Number of females	-1.788	7.097*	4.092	3.147	12.293 **	13.074 *
Above 15 years	(3.354)	(3.720)	(3.955)	(4.356)	(5.288)	(7.244)
Time spent by HH on	-0.349 ***	-0.366 ***	0.005	-0.217 **	-0.661 ***	-0.422 **
Water collection	(0.090)	(0.102)	(0.106)	(0.102)	(0.136)	(0.175)
Season dummy Winter	-26.608 *	-10.240	15.817 *	5.694	16.988	26.106
	(13.777)	(9.469)	(8.222)	(9.516)	(12.230)	(17.572)
Season dummy Summer	-24.915	26.269	-36.407 ***	-25.091 **	-12.043	16.318
	(15.630)	(22.515)	(8.573)	(10.374)	(12.975)	(19.576)
Post-Monsoon	-8.599	3.469	1.548	9.215	20.361 *	40.619 **
	(11.111)	(7.196)	(7.439)	(8.817)	(10.818)	(16.747)
Inverse Mills Ratio	-105.685 **	-178.381 ***				
	(46.699)	(53.772)				
Constant	-766.056 ***	-785.004 ***	-315.308 ***	-210.905 *	-2250.739 ***	-1764.268 ***
	(240.219)	(229.418)	(116.266)	(127.484)	(382.770)	(642.485)
Observations	1686	1318	1215	933	675	345
R-squared	0.223	0.231	0.144	0.163	0.145	0.138

*** 1%, ** 5%, * 10%, The values in parentheses () are standard errors.
Note. For a description of these variables, see notes to tables 2 and 3.
Source: The Indian Time Use Survey, own calculations.

In the labour supply literature, a distinction is often drawn between the "extensive margin" of labour supply (as when people who were not previously working get a job) and the "intensive margin" (as when people who are already working decide to supply more or fewer work hours). The same terminology is useful here. Reading Tables 4 and 5 together, Table 4 shows that the presence of literate females in the household is important for the "extensive margin" (i.e. for school attendance), but table 5 indicates that, conditional on school attendance, this variable is not important at the "intensive margin" (i.e. in determining the amount of time spent *by students* on their schooling).[21] Similarly, the education of the head of household seems to matter more at the extensive margin of attendance than at the intensive margin of hours studied.

Income (more exactly, monthly per-capita expenditure) does not have a robust association. It has a statistically significant *negative* association for 6 to 10 year old girls and 11 to 14 year old boys and girls. The "perverse" sign could be due to measurement error of this variable (which we discussed above) or due to children from richer households attending better schools – note that quality could either lead to higher or lower time on home work.

5 Quantitative implications

In rural India in 1999, over thirty percent of boys aged 11 to 14, and over forty percent of girls, did not attend school. Tables 4 and 5 report the correlates, across individual households, of school attendance and human capital investment time – but what do Tables 4 and 5 imply about which factors might matter more? How much was due to the barriers of caste? How much did the poor education of parents, which might produce ignorance of the benefits of education, actually matter? Is low family income, and a consequent need for immediate earnings by children, the key factor? Or is the quantitatively important explanation to be found in the low quality of the education which is available or the simple lack of schools?

To address these questions, we explore the quantitative implications of the econometric estimates of the determinants of school attendance (reported in Table 4) and the investment time estimates (reported in Table 5). We perform five "thought experiments", assuming that the influence of all the other covariates reported in Tables 4 and 5 remains constant:

(A) Remove the influence of Scheduled Caste or Tribe (SC/ST) membership.

(B) Assume that all families have incomes of Rs. 400[22] or more (i.e. all families with less income than the median for rural households are brought up to that level).

(C) Assume that all heads of household have at least a high school (i.e. upto secondary level) education.

(D) Assume that all families have at least one literate female adult.

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[21] Which also implies that it would have been inappropriate to use a single equation Tobit specification for estimation of the determinants of HK_i.

[22] This is the median household monthly per-capita income for rural households.

(E) Increase the quality and availability of local schooling to the sample median, in those states that fall below the median.

We report the results of these calculations in Table 6. Although simulation E (increasing quality and availability of all schools to the sample median) is intended as an example of feasible policy intervention, simulations A to C are not intended to be "realistic". Rather, the intention is to illustrate, for comparison purposes, the impacts associated with "large" changes (e.g. the end of caste status in India – Simulation A). We do not pretend that such changes are feasible policy choices.

The "No Change" simulation is performed in the following manner. We use estimates from Table 4 and a random error term that we generate[23] to predict for each child (*i*), his/her probability of attendance, p_i. We then compare this probability p_i with a random variable (X) that we generate from the uniform distribution with support [0,1]. We set the child *i* as attending if $p_i > X$ and as not attending, otherwise. We can now calculate the simulated attendance rate for the entire sample using this information (i.e. attending or not attending) for each child. We perform 1000 simulations and report the simple average attendance rate in Table 6. For human capital investment time, we do the following. For each child (*i*), if the child is not attending (from the above simulation on attendance), we set this time to be zero. Otherwise, we use the estimates from Table 5 and a random error term that we generate[24], to get the predicted human capital investment time (H_i). We then compute the median and median over all positive values. We perform 1000 simulations and compute a simple average of these medians and report it in Table 6.

For each of the thought experiments (A)-(E) above, we perform a simulation similar to the above. The only difference is that for each experiment, we change the attributes of certain children – e.g. in experiment (A), we take every child who belongs to Scheduled Caste (SC) or Scheduled Tribe (ST) and set him/her as non-SC or ST; in experiment (B), we take all children who have a household monthly per-capita expenditure less than the median (Rs. 400) and set their monthly per-capita expenditure as Rs. 400; in experiment (E), we raise to median quality and availability of schooling, the quality and availability of schooling for all children who are associated with less than the median. Note that in all the cases, those children who are already associated with the "superior" value of the attribute are untouched, e.g. those children who are associated with monthly household per-capita expenditure of Rs. 400 or more are left alone.

The differences (between each simulated outcome and No Change) can be interpreted as the simulated outcomes of these policy thought experiments. In presenting these results, we are aware that we are comparing a plausible policy scenario about changes to the supply of schooling (raising school quality and availability to the observed median) with several far less plausible scenarios (e.g. no rural household having income less than the 1999 median), which might

[23] Given that this is a probit model, this error term is drawn from the standard normal distribution.

[24] This is drawn from a normal distribution with mean 0 and variance equal to the variance of the error term from the regression of the determinants of human capital investment time (equation (3)). As is well known, an unbiased predictor of this variance is the root mean square error from the regression – which we use.

affect the demand by households for education. We believe that attenuation bias due to measurement error will mean that we have probably *underestimated* the true association between school quality and schooling choices. Nevertheless, our basic conclusion is that the influence of the supply of poor school quality on the school attendance decisions of rural families in India is large relative to the influence of personal characteristics like scheduled caste membership or low household income.

Table 6
Results of simulation on quantitative implications

	6-10		11-14		15-18	
	Boys	Girls	Boys	Girls	Boys	Girls
			No change[a]			
Attendance	65.50 %	61.80 %	62.60 %	53.80 %	36.10 %	25.20 %
Attendance (SC/ST)	60.90 %	56.30 %	58.60 %	47.50 %	32.20 %	19.90 %
HK time (median)[b]	365.24	346.66	400.93	320.92	0	0
HK time>0 (median)	442.48	441.72	492.25	489.58	531.37	515.19
HK time (median, SC/ST)	331.85	294.98	362.56	39.83	0	0
HK time>0 (median, SC/ST)	432.31	429.62	477.26	469.02	508.14	485.36
			Simulation A[c]			
Attendance	67.30 %	63.90 %	63.10 %	54.90 %	36.50 %	25.30 %
Attendance (SC/ST)	65.60 %	61.40 %	59.80 %	50.40 %	33.10 %	20.30 %
HK time (median)	373.67	355.06	408.98	347.69	0	0
HK time>0 (median)	443.88	440.35	497.53	498.71	541.87	524.13
HK time (median, SC/ST)	360.06	329.36	388.26	164.7	0	0
HK time>0 (median, SC/ST)	437.13	427.75	494.45	499.99	543.62	521.75
			Simulation B[d]			
Attendance	65.30 %	62.60 %	62.30 %	54.60 %	36.90 %	25.90 %
HK time (median)	362.85	346.16	397.11	329.32	0	0
HK time>0 (median)	440.71	437	489.1	484.72	531.75	513.59
			Simulation C[e]			
Attendance	71.90 %	69.50 %	72.60 %	62.90 %	43.50 %	31.22 %
HK time (median)	371.24	351.33	437.46	397.31	0	0
HK time>0 (median)	426.65	416.27	490.74	489.34	537.77	485.82
			Simulation D[f]			
Attendance	68.10 %	69.50 %	66.70 %	60.50 %	40.50 %	31.00 %
HK time (median)	373.34	355.54	420.41	387.49	0	0
HK time>0 (median)	440.71	421.24	493.3	492.45	526	523.31

Table 6 Cont.
Results of simulation on quantitative implications

	6-10		11-14		15-18	
	Boys	Girls	Boys	Girls	Boys	Girls
Simulation E[g]						
Attendance	73.60 %	69.20 %	66.00 %	59.70 %	46.60 %	28.60 %
Attendance (SC/ST)	69.40 %	64.50 %	62.40 %	53.60 %	43.60 %	22.80 %
HK time (median)	422.95	409.37	433.7	389.42	1.14	0
HK time>0 (median)	471.73	471.77	506.61	496.26	561.57	533.89
HK time (median, SC/ST)	399.36	381.04	405.87	290.57	0.54	0
HK time>0 (median, SC/ST)	461.04	462.69	494.23	478.52	543.07	509.3

Note:

a. The No Change and other simulations are explained in great detail on pp. 14-15.

b. All medians in minutes per normal day.

c. Removes the impact of SC/ST.

d. Takes children in households with less than median income to the median.

e. Sets the education level of the household head to at least high school.

f. Ensures that there is at least one literate female adult in the household.

g. For children in states lying below the median quality and availability of schooling, makes these equivalent to the median.

Source: The Indian Time Use Survey, own calculations.

Because most people are not members of Scheduled Castes or Scheduled Tribes, most people are therefore not themselves affected by the marginalization of SC/ST members, so there is not a large aggregate impact, for the population as a whole, when the stigma of membership in these groups is removed – e.g. for 6 to 10 year olds, we simulate an increase of 1.8 percentage points in the school attendance of boys, and 2.1 percentage points for girls. However, one should not think of the SC/ST issue just in terms of aggregate human capital formation and aggregate growth. If, for the same age group, one considers only members of scheduled castes and tribes, the change in attendance rates and median human capital investment time is clearly larger: 4.7 percentage points and +28.21 minutes for boys (+5.1 percentage points and +34.38 minutes for girls).

Nevertheless, given the continuing political controversies surrounding the administrative mechanisms (such as reserved places) used to encourage the educational attainment of Scheduled Castes/Tribe and other disadvantaged children, we note that the schooling of SC/ST children would also benefit from general improvements in school quality and availability – which might be a policy choice with more widespread appeal. If there were no special treatment of SC/ST members, but the local school quality was improved to median standards, the increase in school attendance of 6 to 10 year old SC/ST boys is simulated to be 8.5 percentage points (for girls, 8.2 percentage points). A general policy of school improvement would thus provide, for SC/ST members benefits which would be larger than the improvement to be expected from policy targeted on SC/ST members alone. Of course, a combination of improvement in quality and re-

moval of barriers for SC/ST would lead to much larger improvements for both the general population and the SC/STs.

The results of our Simulation B – which increases the income of all below-median households to the median monthly rural expenditure level – can be summarized as: "little impact – for a very large thought experiment". The small size of the coefficient on income in Table 4 and 5 drives a strong conclusion – that inequality in schooling and human capital investment may play an important role in generating inequality in income, *but not so much the reverse*.[25]

The major message of Table 6 is two-fold: [a] the importance of public policy in the supply of schooling and school quality for current educational choices and [b] the lagged impact of past educational attainment of parents on the current educational choices they make for their children.

For the population as a whole, we estimate the impact of school quality improvements for 6 to 10 year olds to be + 8.1 percentage points in boys' school attendance and +7.4 percentage points for girls. As more students shift into the positive homework time zone, the median human capital investment time would also increase substantially. For the 11 to 14 age group, the school quality impact is estimated at +3.4 percentage points attendance for boys and +5.9 points for girls, and about 32 and 69 more minutes of human capital investment time for boys and girls, respectively.

Our Simulations C and D represent an attempt to model the educational choices of rural Indian families, if they were already starting from the position of all having at least a high school education for the household head and had no problem of female illiteracy, respectively, holding everything else constant. Since most of the household heads are men, Simulation C would mostly affect (in a direct sense) men, whereas Simulation D would affect women. Moreover, Simulation D can be expected to affect the next generation (as compared to Simulation C) because it could mean the presence of an educated daughter or daughter-in-law. Both these simulations show large intergenerational impacts on attendance and human capital accumulation time. For example, for Simulation C, (all heads of household have at least high school) for the 11 to 14 age group, we estimate the school attendance of boys and girls to increase by 10 and 9.1 percentage points, respectively. For Simulation D (all families have at least one literate female adult), the corresponding figures are 4.1 and 6.7 percentage points, respectively. However, while these impacts (including impacts for other age and gender groups) are roughly comparable to or lower than those due to improvements in quality and availability (i.e. Simulation E), the salient question is: how can we change the education of parents?

Our own conclusion from all this is the importance of the supply side of the schooling equation. We conclude that the most relevant and important policy option for increasing attendance and human capital accumulation in rural India is to improve the quality and availability of schooling. This of course does not imply that other policies should not be pursued, particularly in con-

[25] However, as noted above, this result has to be seen in light of the possible measurement error of the expenditure variable.

junction with improvements in quality and availability – and the importance of parental education in influencing the schooling of their children is a reminder that the benefits of more education are received both by today's children and by subsequent generations of children.

6 Conclusions and discussion

This paper has matched state level data on the quality of schooling available in rural India with micro-data on the time use of Indian households. The merged data has been used to estimate models of probability of school attendance and the total time devoted to investment in education. We conclude that more of the inequality in human capital investment time in rural India can be explained by the poor quality and availability of schooling to potential students than can be attributed to parental education, or income, or the barriers of Scheduled Caste and Tribe membership.

We think this finding is important because a very large literature emphasizes the benefits of a more highly educated population. Many studies have concluded that more years of schooling produces higher individual earnings – Temple (2001: 484), for example, concludes that in OECD nations: "the private rate of return to an additional year of schooling is typically between 5 and 15 percent". As well, health and social outcomes, such as the relationship between mother's education and the birth weight of babies in the UK (e.g. Chevalier and O'Sullivan, 2006) or the Height-for-Age of children (e.g. Handa, 1999b; Osberg et al, 2009) have been conclusively linked to education. Wolfe and Haveman have added up the value *to other people* of the changes in health, criminal activity, cognitive development of children, volunteer hours, etc., which are positively associated with increased education and conclude: "a conservative estimate of the value of non-labour market influences is of the same order of magnitude as estimates of the annual marketed, earnings-based of one more year of schooling" (2001:245). Adding together these externalities to others and the private impact of schooling on individual earnings, the aggregate social return to education is a crucial component of economic development.

However, we have to label our findings as "tentative" because of the difficulties of proving causality. Angrist and Krueger (1999) remain a useful example of a large literature in labour economics which stresses the difficulties involved in unambiguous assertions of causality, in non-experimental social science settings. We are not reporting econometric estimates drawn from an environment (like the Progresa experiment in Mexico) in which we can say that the treatments of interest (e.g. school quality, parental education) were randomly assigned in the population. Our results are, strictly speaking, cross-sectional correlations using naturally occurring data which are *consistent with* the hypothesis that variables like local school quality play a causal role in family decisions about human capital investment, but our data cannot reject the hypothesis that other explanations are also possible. Substantively, our results underline the conclusion of Dreze and Sen (2002) on the important – indeed crucial – role of public policy in

the human capital formation that is a prerequisite of sustained development. There is really no adequate substitute for good education – and the failure to provide universal access to high quality schooling is a major failure of collective choice in India.

We also hope that we have been able to provide an illustration of the value of time use data, and how it can be used in combination with other data sources, in understanding the development process. Greater investment in schooling and other forms of human capital is but one example of the many structural changes of development that involve decisions about time use within households. These decisions lie outside the domain of market transactions and if analysis of these processes were to be restricted to the use of data on market expenditures, much would be missed. However, because virtually all human activities require time, data on time use – particularly when it is combined using geo-coding with other data on the characteristics of local communities – can often be of great assistance to effective analysis of the development process.

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The time cost of access to food – Distance to the grocery store as measured in minutes

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Abstract

Time use diaries are rich in information, including where and when respondents travel from place to place. Travel estimates, as well as variety of contextual information on travel, can be generated from time use data. However, using the data for travel analysis is difficult and involves detailed understanding of how the data are coded. Presented here is a methodology for estimating travel time using the time diaries from the 2003-07 American Time Use Survey. As an illustration of the methodology, the authors estimate travel time to grocery shopping. These estimates are of interest as a policy concern in the United States is whether or not some poor areas of the country have access to supermarkets that offer the variety of foods needed for a healthy diet, and in particular, fresh fruits and vegetables. Neighborhoods that have limited access to supermarkets are referred to as "food deserts." The authors found that individuals living in low-income areas with limited supermarket access spend significantly more time (an average of 19.5 minutes) traveling to grocery shopping than the national average (15 minutes), and in addition, they grocery shop less frequently, and they are more likely to be accompanied by children during travel to grocery shopping.

JEL-Codes: C81, R41, I30

Keywords: Time use, grocery shopping, food desert, trip chaining, transportation, food access, travel time

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1 Introduction

Low-income persons may have limited access to nutritious food, and as a consequence, have poor diets which may lead to obesity and diet-related diseases. This issue of "food deserts," neighborhoods that do not have access to supermarkets, received attention in the United States Congress, and the Food, Conservation, and Energy Act of 2008 directed the U.S. Department of Agriculture to conduct a study to assess the extent of areas with limited access to nutritious, affordable food. The resulting report was released in June 2009, *Access to Affordable and Nutritious Food: Measuring and Understanding Food Deserts and Their Consequences, Report to Congress* (Ver Ploeg, et al., 2009).

An aspect of the report's analysis was identifying the time cost of access to food, that is, measuring the travel time to grocery shopping. Measuring travel time can be a complex task as individuals frequently make stops on the way to their main destination, and so creating definitional rules on what to include across a population can be difficult. Time use diaries are rich in information, including travel from place to place, however using the data for analyzing travel can be difficult. Despite the difficulties, time use data is a rich source of information, not only on travel time, but also contextual information that can inform a policy issue such as food deserts.

Our original research goal was to identify and measure travel time to grocery shopping looking at different levels of supermarket access and at different levels of individual and neighborhood income. Here we focus on presenting the detail and methodology used for identifying and measuring travel time. The contribution of this research is the methodology used to measure travel time by using time diary data, specifically, the American Time Use Survey (ATUS) data, to study transportation issues. Also, we present extensive estimates and findings for our application, travel time to grocery shopping, to illustrate the insight gained from using time use data.

2 Background

In identifying and measuring travel time to grocery shopping, we built on concepts from several fields. We drew from the travel/transportation literature in order to understand how individuals transport themselves from place to place, and how transportation analysts identify and measure trips and trip distances. We considered the time use literature and in addition, the research area of food access, which is a spatial concept. These are all research areas that have long histories and extensive bodies of literature. Here we focus only on the concepts that are relevant to our research on travel time to grocery shopping.

2.1 Transportation

Travel data is collected and analyzed in order to understand individuals' travel behavior for a variety of policy, program, and marketing purposes, such as determining whether travel infrastructure capacity is sufficient, managing travel demand, determining whether individuals' travel is more- or less-energy efficient over time, and determining optimal locations for retail establishments. The transportation literature has well-defined concepts. Relevant here are the concepts of: anchor, direct trip, trip chain, intervening stop, and tour. Quoting from McGuckin and Nakamoto (2004, no page number):

1. *Anchor: A primary or substantial trip destination.*
2. *Direct trip: A trip that travels directly between two anchor destinations, such as a trip from home to work.*
3. *Chain: A series of short trips linked together between anchor destinations, such as a trip that leaves home, stops to drop a passenger, stops for coffee and continues to work.*
4. *Intervening stop: The stops associated with chained trips.*
5. *Tour: Total travel between two anchor destinations….Note that it is possible to have the two anchor destinations be the same location, as in a home-to-home or work-to-work tour*.

Anchors are typically defined as home and work. Because individuals may make stops during their travel between anchors, an extensive literature on "trip chains" has developed.[1] An example of a trip chain would be: Travel from home to school (drop off child), travel from school to café (buy coffee), then travel to workplace. The anchors are home and work, and when the individual arrives at the workplace, the tour is completed, but only after other destinations have been visited. An additional concept is that of *dwell time*, the length of time spent at a destination. A trip chain can be defined as ending if the individual spends more than a certain amount of time at a stop, which would indicate that the stop is not an intervening stop but a destination.

The above is the *trip-based* approach to analyzing travel. Another approach is the *activity-based* approach of modeling travel behavior. The activity-based approach "views travel as a derived demand; derived from the need to pursue activities distributed in space." (Bhat and Koppelman, 2003). Travel is not demanded for itself, but for the ability to fulfill an individual's demand for consumer products, or to enable an individual to commute to work.[2] This approach looks at the individual's participation in specific activities. As a result, the activity-

[1] McGuckin and Nakamoto (2004) and Strathman and Dueker (1995) are excellent introductions to trip chaining concepts. See Anas (2007) for a discussion of consumption and trip chaining.

[2] The literature on travel demand models is extensive. Cascetta (2009) has a thorough overview of the types of travel demand models, and Sheppard (1980) presents travel demand theory including the spatial issues involved in the individual's decision of whether to travel. Travel is a spatial activity, and research investigating the spatial aspect include Lin and Long (2008), who discuss the concept of neighborhood and neighborhood type and how the neighborhood built environment affects travel behavior.

based approach uses time-use data to analyze the individual's entire day of activities, and the substitution of in-home for out-of-home activities, and vice versa. This approach focuses on sequences of activities and travel. It might appear that the activity-based approach would be relevant to the question of food deserts, however we are not modeling whether or not an individual goes grocery shopping, but instead measuring their travel time. Consequently, we follow the trip-based approach in our analysis.

2.2 Time use and travel

Although there are several data sources and many studies on time spent in travel, relatively little has been done using time diary data, that is, time use data that includes a respondent's entire day and not just travel time. The transportation literature refers to *time use data*, although for most surveys the respondents are asked to report only the travel and travel-related activities, not their entire day. Full-day diary surveys are sometimes referred to in the transportation literature as *activity diary surveys* (Mokhtarian and Chen, 2004). Pas and Harvey (1997) asserted that travel-behavior researchers could benefit from time use research, and that time use data is a "potentially rich, untapped resource" (p. 331) for transportation analysis. Kitamura, Fujii, and Pas (1997) identified that full-day diary surveys could be useful for transportation planning and called for more time use data collection and research. Harvey and Taylor (2000) used national time use data from Canada, Norway, and Sweden to study social context and travel behavior. They concluded that individuals with low social interaction tend to travel more.

Recent methodology and research literature analyzing travel with full-day time diary data is sparse, and some key works are unpublished. Allard (2009) discusses how to use the American Time Use Survey data to estimate travel times. Included is detail on the ATUS coding rules. Understanding how the data are coded is necessary in order to correctly define and measure a type of travel such as commuting. Brown and Borisova (2006), using 2003-04 ATUS data, also discuss how the ATUS can be used to measure commuting time and travel time to grocery shopping. Bose (2006) discusses technical detail for using the ATUS for travel estimates. Bose and Sharp (2005) compare trip estimates using the National Household Travel Survey and the ATUS. Much of their paper is devoted to coding and other technical issues. They conclude that while the ATUS does not provide the transportation detail needed by transportation modelers and planners, the ATUS allows for research on the relationship between travel and other activities. In all of these papers, the importance of understanding the data coding detail is stressed. If the coding definitions and coding rules are not understood, the research will not be capturing the desired travel time.

Christian (2012) used the ATUS to analyze commuting time and health-related activities. For his research question, he summed all travel time from home to work and from work to home, regardless of the coded purpose of the travel in order to measure total time commuting. He

concluded that longer commutes are associated with declines in health-related activities, and in particular, sleep time.

George and McCurdy (2009) also discuss ATUS travel time coding as part of determining where individuals are during the course of the day. Their research is on modeling human exposures to environmental pollutants, and identifying where activities take place is necessary for their analysis. They used the 2003-07 ATUS data to analyze work-related travel and discussed coding difficulties that they described as "inconsistent treatment of trips to and from work and during the work period" (p. 101). They also concluded that the missing location codes for personal care activities needs to be addressed with imputation.

Srinivasan and Bhat (2008) used the 2003-04 ATUS to look at travel to study "joint activities," that is, activities where the respondent was accompanied by another person, in order to analyze activity duration and location. They found that joint activities are typically of longer durations, and travel related to these activities may involve pick-up and drop-off of the activity companions.

Spissu, et al., (2009) used Swiss time use data to identify and model discretionary activities and the accompanying travel. Their unique multi-week data allowed for analysis of inter-person variation that is especially important for activities that are not usually done daily. However, multi-week time use data is not available for the United States, and so here their research serves mainly to understand the limits of analysis with single-day diaries.

Millward and Spinney (2011) used the Halifax Space-Time Activity Research data that includes both time diaries and Global Positioning System (GPS) tracking of travel to analyze travel across the rural-urban continuum. They conclude that analyzing travel using the urban-rural dichotomy is insufficient, and more detail on the rural-urban continuum is needed to understand time use and travel behavior. The authors utilize an exceptionally detailed dataset that tracked respondents' locations on their diary days.

2.3 Food desert/access to nutritious food

A policy concern is that individuals in some neighborhoods do not have access to supermarkets, and as a consequence, do not have access to affordable and nutritious food. These "food deserts," or low-access areas, are of particular concern if the residents are low income as their options for getting to the supermarket may be limited, and they may have poor diets which could lead to obesity and diet-related diseases. Although the concept of a food desert is relatively recent,[3] there has been considerable research on the topic in the last few years. The U.S.

[3] Cummins and Macintyre (2002) state: "The term 'food desert' was reputedly first used by a resident of a public sector housing scheme in the west of Scotland in the early 1990s. It first appeared in a government publication in a 1995 document from a policy working group of the Low Income Project Team of the then Conservative government's Nutrition Task Force." (Beaumont, J., T. Lang, S. Leather, C. Mucklow. *Report from the policy sub-group to the Nutrition Task Force Low Income Project Team of the Department of Health.* Radlett, Hertfordshire: Institute of Grocery Distribution, 1995.)

Department of Agriculture report to Congress (Ver Ploeg, et al., 2009) contains new research as well as extensive synthesis of previous research, and so provides a good overview of food desert literature. Another good overview is in Jiao, et al., (2012), which focuses on identifying and defining food deserts. For an international overview, Beaulac, et al., (2009) authored a synthesis of the literature on food deserts that includes research on the United States as well as other developed countries.

A focal point of food desert research is to look at neighborhoods by income levels and other demographic characteristics. Morland, et al., (2002) focused on (U.S.) Mississippi, North Carolina, Maryland, and Minnesota, and looked at the wide array of retail venues that sell food and at several measures of neighborhood wealth. They concluded that poor and minority neighborhoods have less access to healthy foods. Morris, Neuhauser, and Campbell (1992) did a relatively early study looking at (U.S.) rural persistent-poverty counties and access to supermarkets and the cost of the Thrifty Food Plan marketbasket relative to food stamp benefit allotments. They concluded "... that in persistently poor rural American, low income households, including those receiving food stamps, are at an increased risk of food insecurity" (p. 56S).

Much of the food desert/supermarket access literature looks in depth at one city or a region. An example is Zenk, et al., (2005) who studied Detroit, Michigan (U.S.) by analyzing the demographics of census tracts and their access to supermarkets, and concluded that impoverished African American neighborhoods had, on average, a longer distance to the nearest supermarket than impoverished White neighborhoods. However, they acknowledge that a missing aspect of their analysis is travel time and they stated "travel time may be a more informative indicator of accessibility than physical distance" (p. 664). Another example is Apparicio, Cloutier, and Stearmur (2007), who studied Montrél's (Canada) neighborhoods as to their access to healthy foods. They developed three measures of accessibility to supermarkets using different geographic distance definitions. They concluded that it is important to use more than one indicator for identifying food deserts, and different indicators measure different dimensions of food deserts.

Rose and Richards (2004) state that the "time issue is important" (p. 1082) in looking at access, and developed a measure that combined where groceries were purchased (supermarket or smaller store), travel time (self-reported), and car ownership using the National Food Stamp Program Survey data. Their data were nationally representative, and they concluded that easy access to supermarkets was associated with higher household fruit consumption.

Time-use data is well-suited to analyzing the "time distance" to grocery shopping. Indeed, "travel time is the true indicator of access, for which distance attempts to account." (The Reinvestment Fund, 2012, p. 14). Some researchers estimate travel time from the geographical

physical distance to the supermarket[4] and some studies survey individuals on time spent in all travel or just on grocery-related travel.[5] However, in addition to providing an alternate measure to the geographical physical distance to a grocery store—which may not fully capture the time cost of travel to grocery shopping in a congested, urban area—time-use data also provide information about how individuals fit grocery shopping into their lives. Looking at the time use patterns of individuals who grocery shop, along with contextual information such as their mode of transportation and whom they were with, allows for a better understanding of the ease or the difficulty of the shopping trip. For our application, food deserts, time distance to grocery shopping provided an additional indicator for measuring a complex policy problem.

3 Methodology and data

We used a typology developed by our colleagues to define low-, medium-, and high-supermarket access by census tract.[6] High access is within 0.5 mile of a supermarket, medium access is 0.5 to 1.0 mile, and low access is more than 1 mile. In addition to identifying level of access, the typology also includes indicators for low-income census tracts, tracts where 40 percent or more of the population live in households with income less than 200 percent of the poverty threshold.[7]

For estimates of average time spent in travel to grocery shopping, we used the pooled 2003-2007 American Time Use Survey (ATUS) data.[8] The Bureau of Labor Statistics' ATUS is a continuous survey that began in 2003, collecting time use data nearly every day of the year,

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4 Charreire, et al., (2010) reviewed geographic information systems (GIS) methods used to define the food environment. The studies they reviewed used Euclidean distance, Manhattan distance, or network distance to proxy for travel time.

5 Rose and Richards (2004), and Jilcott, et al., (2011). Both of these studies looked at Supplemental Nutrition Assistance Program (SNAP) recipients only.

6 The 2000 Census tract boundaries were used. Census tracts are small, statistical subdivisions of a county, with optimally 4,000 residents/tract. There are 65,443 census tracts in the United States. See http://www.census.gov/geo/www/reference.html for more info.

7 Our colleagues Vince Breneman, Phil Kaufman, and Tracy Farrigan developed this typology. Their goal was to develop area measures of access at the census tract level. They used a list of stores authorized to access Food Stamp Program/Supplemental Nutrition Assistance Program benefits, and a proprietary listing of supermarkets (from Nielsen company) to identify supermarkets, which are stores with sales of at least $2 million a year, and contain all major food departments (including fresh meat and poultry, produce, dairy, dry and packaged foods, and frozen foods), and put these supermarkets in a GIS (geographical information systems) format. They measured the distance to the nearest supermarket using the Socioeconomic Data and Applications Center grids data at the 1-square-kilometer grid level for spatial computation of distance to supermarket, calculated from the geographic center of the grid. Low-income areas were identified as grids with 40 percent of more of the residents in households with income less than 200 percent of the poverty threshold. Grids were summed up to the census tract level for the typology. More detail on the methodology of the typology is in Ver Ploeg, et al., (2009) chapter 2 and appendix C.

8 We used the U.S. Department of Labor Bureau of Labor Statistics ATUS User's Guide: Understanding ATUS 2003 to 2009 (2010), the American Time Use Survey Coding Rules (2010), American Time Use Survey Activity Coding Lexicons (various years), and the Current Population Survey: Design and Methodology (2006).

with U.S. Census Bureau conducting the interviews. One individual age 15 or older from each sampled household is interviewed about his or her activities for the 24-hour period from 4 a.m. the day before the interview to 4 a.m. on the interview day. Survey respondents are asked to identify their primary activity if they were engaged in more than one activity at a time. They are also asked to report where they were and whom they were with for most diary activities. The ATUS also includes demographic, labor force participation, and household information, along with a limited amount of geographical information.

If the respondent reports travel from place to place, moving from one address to another, they are asked to report their mode of transportation. As a consequence, the ATUS time diary data contains extensive information about Americans' travel. The data specify travel as an activity, and record mode of transportation and whom the respondent was with when traveling. If the travel was by vehicle, the data include whether the respondent was the driver or passenger.

The pooled 2003-2007 ATUS microdata files contain 72,922 completed interviews. Of those, 11,726 observations, 16 percent, are of respondents age 15 or older who grocery shopped on their diary day. The ATUS Respondent, Roster, Activity, Activity Summary, Who, ATUS-Current Population Survey, and Replicate Weights files were used for our research. In addition, because of Census Bureau's cooperation, we were able to use the confidential respondent location data in order to determine respondent's census tract.

Grocery shopping is defined in the ATUS as activity 070101, and we restricted grocery shopping to the locations of grocery store, restaurant or bar, other store/mall, outdoors away from home, or other place.[9] Grocery shopping done at other locations was not included so as to exclude online grocery shopping.[10] A limitation is that we do not know where the grocery shopping was done, that is, if it was the closest retail venue to the respondent's home or not. We also do not know if it is the preferred grocery shopping venue. We just know that it is the one that the respondent shopped at on his/her diary day.

We use the description *travel to grocery shopping* as it is precise in what we are measuring, however for ease of exposition, we also use the phrase *travel to grocery store*, although grocery shopping can be done at other places and our research is not restricted only to grocery shopping done at grocery stores. Likewise, we use *grocery store* or *supermarket* instead of *grocery shopping location*.

To deal with the complexities of trip chaining, ATUS generally codes the purpose of a travel activity based on the activity that follows the travel episode and its location. For example, if a respondent travels directly from home to his/her workplace, and starts working immediately

[9] ATUS activity code 070101 and TEWHERE = 4, 6, 7, 9, 11.

[10] TEWHERE = 1, 2, 5, 10. If the location of grocery shopping was miscoded as a mode of transportation, we recoded the location as "Unspecified place," and if the mode of transportation was miscoded as a location, we recoded the mode as "Unspecified mode of transportation." TEWHERE=89 for Unspecified place, TEWHERE=99 for Unspecified mode of transportation.

upon arrival, then the travel episode is coded as 180501, Travel related to working.[11] If the respondent went grocery shopping after work, the time spent traveling from the workplace to the store is coded as ATUS activity 180701, Travel related to grocery shopping. The exception to the "looking ahead" rule is when the respondent is traveling home, in which case the purpose of the travel is coded based on the activity that preceded it. For example, if someone grocery shops and then travels home, the travel episode would be coded as activity 180701, Travel related to grocery shopping. As a result, calculating travel time to the grocery store using the ATUS activity codes is complicated by the fact that some diaries will have only one "side" of travel related to grocery shopping coded as travel related to grocery shopping and others will have both sides—the going and coming home—of the trip coded as travel related to grocery shopping. As a result, just averaging the durations of all the occurrences of activity 180701 would not necessarily provide the travel time to grocery shopping.

To account for trip chaining travel behaviors and ATUS travel coding, we estimated average time to the grocery store as follows. For each time diary with grocery shopping as an activity in the respondent's time diary, we added up the times associated with all legs of travel from home to the place where the respondent reported grocery shopping, that is, all activities coded 18xxxx Traveling. We also added the time associated with all the legs of travel from the time the respondent reported grocery shopping until the respondent arrived home. We then compared the total travel time home-to-shopping to the total travel time shopping-to-home, and chose the shorter total time as the "time distance" to grocery shopping. In doing this we did not have to consider the coded purpose of the travel, which may be misleading, and we also did not have to consider the dwell time, the time spent on an activity between two travel occurrences. All the characteristics of travel associated with grocery shopping that we analyzed, such as the mode of transportation, were associated with the shorter duration travel side. In cases where the respondent did not start the day at home or did not end the day at home, we only had information for one side (home to grocery shopping or grocery shopping to home). In these cases we used the total travel time for that side as the time distance to the grocery shopping. See Appendix on Detailed Coding Rules for more information.

This streamlined method of identifying travel associated with grocery shopping is simpler than measures of trip time that put limits on travel legs and on dwell time, and it also avoids mis-identifying travel due to the data coding specifics. Because home is usually the ultimate destination of the individual, and so is also the destination of groceries, our method is conceptually consistent with the purpose of the trip. Our method is similar to Christian (2012), who summed all travel times from home to work and work to home, however we compare the to-grocery-shopping and from-grocery-shopping times to use the shortest of the travel times.

For most grocery shoppers in the ATUS data, the shortest travel time was between grocery shopping and home, however for 6.4 percent of the grocery shoppers in the ATUS data, the shortest time distance was from work. We decided that the work location is a relevant means

[11] ATUS coding lexicons are available at: http://stats.bls.gov/tus/lexicons.htm

of access to grocery shopping, so for these respondents we used their work-to-store or store-to-work travel time.[12] Consequently, the average time estimates we present use two anchors, home and work.

As discussed above, we did not consider dwell times or limit trip chains to a number of trip legs, as we wanted to measure travel time to grocery shopping as individuals fit it into their lives. This is unlike some of the travel literature that strives to measure the shortest commuting time without stops between home and workplace. Because of our concern about capturing the complexity of individuals' lives, and in particular, low-income individuals, measuring travel time and travel patterns as reported on the diary day was important to our analysis. A diary with an example of a Home to Grocery Shopping to Home travel tour is in table 1. A diary with an example of Home to Work to Grocery Shopping to Home travel tour is in table 2.

Estimation procedures outlined in the *ATUS User's Guide* (Bureau of Labor Statistics, 2010) were followed. All estimates presented were weighted to be nationally representative. Averages were calculated as the mean. Standard errors were calculated according to Section 7.5 of the *ATUS User's Guide*, using the balanced repeated replication method and the ATUS Replicate Weights file. A 90-percent level of confidence was used to determine whether estimates were statistically different. All differences between estimates discussed in the text are statistically different at the 90 percent level. We followed the BLS standard at the time to suppress estimates for cells with unweighted counts fewer than 60. Estimates were done in SAS 9.2 and Perl 5.6.1.

[12] When we started our research we looked at potential anchors for grocery shopping. The location that was "nearest" grocery shopping in the time diaries was the individual's home (91 percent of grocery shoppers), the location that occurred second "nearest" was workplace (8 percent), the third "nearest" was place of worship (0.5 percent), and fourth was school (0.2 percent). After that the other locations had just a tiny smattering of the share of occurrences that were "nearest." We started with the two anchors home and workplace. We tried adding the third anchor, place of worship, but the programming complexity increased tremendously with three anchors, and we ultimately made the decision to stay with the two anchors home and work.

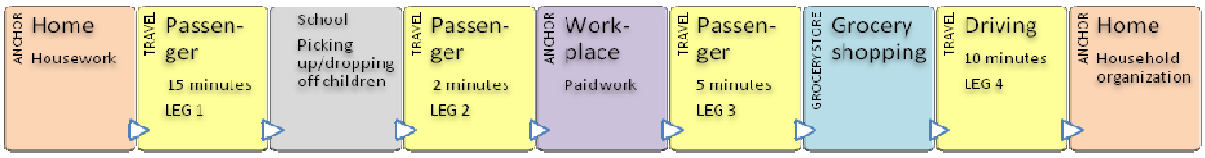
Table 1
Example of home to grocery shopping to home travel

Activity	Start time	End time	Activity	Activity description	Location	Travel time	Total time
1	04:00:00	08:00:00	010101	Sleeping	Not asked		
2	08:00:00	10:00:00	020101	Housework--interior cleaning	Home	ANCHOR	
3	10:00:00	10:20:00	180704	Travel	Driving vehicle	20	
4	10:20:00	13:20:00	070104	Shopping (not grocery, food, gas)	Other store/mall		
5	13:20:00	13:35:00	180901	Travel	Driving vehicle	15	
6	13:35:00	13:45:00	090103	Using clothing repair, cleaning services	Store/mall (not grocery, food, gas)		
7	13:45:00	13:50:00	180701	Travel	Driving vehicle	5	40
8	13:50:00	14:35:00	070101	Grocery shopping	Grocery store		
9	14:35:00	14:45:00	180701	Travel	Driving vehicle	10	10
10	14:45:00	15:45:00	020902	HH organization and planning	Home	ANCHOR	
11	15:45:00	16:00:00	180704	Travel	Driving vehicle	15	
12	16:00:00	16:30:00	070104	Shopping (not grocery, food, gas)	Store/mall (not grocery, food, gas)		
13	16:30:00	16:45:00	180704	Travel	Driving vehicle	15	
14	16:45:00	17:00:00	020902	HH organization and planning	Home		
…	…	…		…			
23	21:40:00	08:00:00	010101	Sleeping	Not asked		

Travel time to grocery shopping = min [LEG 1 + LEG 2 + LEG 3, LEG 4] = min [40, 10] = 10 minutes.
Source: American Time Use Survey (ATUS) 2003-2007, own calculations and illustration.

Table 2
Example of home to work to grocery shopping to home travel

Activity	Start time	End time	Activity	Activity de-scription	Location	Travel time	Total time
1	04:00:00	04:45:00	010101	Sleeping	Not asked		
2	04:45:00	05:15:00	010201	Grooming	Not asked		
3	05:15:00	06:15:00	020201	Food preparation	Home		
4	06:15:00	07:00:00	030101	Physical care for hh children	Home	ANCHOR	
5	07:00:00	07:15:00	180301	Travel	Passenger in vehicle	15	
6	07:15:00	07:20:00	030112	Picking up/dropping off hh children	School		
7	07:20:00	07:22:00	180501	Travel	Passenger in vehicle	2	17
8	07:22:00	11:30:00	050101	Paid work	Workplace	ANCHOR	RESET
9	11:30:00	12:30:00	110101	Eating & drink-ing	Workplace		
10	12:30:00	16:30:00	050101	Paid work	Workplace		
11	16:30:00	16:35:00	180701	Travel	Passenger in vehicle	5	5
12	16:35:00	17:20:00	070101	Grocery shop-ping	Grocery store		
13	17:20:00	17:30:00	180701	Travel	Home	10	10
14	17:30:00	17:45:00	020102	Laundry	Home	ANCHOR	
…	…	…		…			
22	23:00:00	04:30:00	010101	Sleeping	Not asked		



Travel time to grocery shopping = min [LEG 3, LEG 4] = min [5, 10] = 5 minutes.
Source: American Time Use Survey (ATUS) 2003-2007, own calculations and illustration.

4 Access-area estimates

In considering food deserts—low access to affordable, nutritious food—the interest is in low-income individuals and low-income areas. An affluent neighborhood may have zoning restrictions that allow only residential uses of land within a neighborhood or subdivision and so may not contain any retail establishments, and may be categorized as low access according to the typology above. However, affluent households would have the means to travel to grocery shopping. Our focus is on vulnerable subpopulations that may have barriers to access. We define low-income individuals as those living in a household with household income less than or equal to 200 percent of the Federal poverty thresholds according to household size. Low-income areas were defined as census tracts that had more than 40 percent of the residents living in households with income at or below 200 percent of the Federal poverty thresholds.

In order to apply these definitions and access typology (low-, medium-, and high-supermarket access) to the ATUS data, we needed to know the location of the ATUS respondents. The respondent's address and detailed geographical information is suppressed on the ATUS public use files to protect the confidentiality of survey respondents. These data only are available to staff of the U.S. Census Bureau with a need to know this information. As a result, we could do analysis by access level only with Census Bureau cooperation. Because the original project was a Congressionally-mandated study, the Bureau of Labor Statistics and the U.S. Census Bureau collaborated with the U.S. Department of Agriculture to produce the needed estimates. Since the data were restricted to Census Bureau staff, they compiled all estimates.

Using the access typology and definitions above that were defined by census tract, Census identified the access level of the ATUS respondents who grocery shopped on their diary day, and also whether or not they were in a low-income census tract. Of the 11,569 respondents over 2003-07 who grocery shopped on their diary day, 8,305 were able to be assigned an access level. Not all respondents could be assigned an access level for two reasons. First, ERS was not able to assign a level for some census tracts, typically those in Indian Reservations or tracts dominated by National Parks. Second, because of Census Bureau's sample framing method for the Current Population Survey and the American Time Use Survey, sample frames of residents in newly-built housing do not contain detailed geographical information, and specifically census tract information, and so they could not be matched. As a consequence, access-level analysis could be done on 72 percent of the ATUS respondents who grocery shopped.

The ability to utilize the respondents' location information is crucial to this food desert analysis, and allows us to identify whether a supermarket is located near the respondent's residence. However, we do not know where the respondent grocery shopped and we do not know whether the respondent grocery shopped at the closest supermarket. Respondents may selectively shop further from their neighborhood because of price, availability, or preference factors. As a consequence, our estimates may be over-estimates of travel time to the closest su-

permarket. Having stated this, the benefit of analyzing the time diary is that we are measuring what the individual actually did, and how he/she fit grocery shopping into his/her life. Our estimates are, when weighted with the ATUS sample weights, nationally representative estimates of grocery shopping behavior on an average day over 2003-07.

4.1 Travel time by access level

Table 3 shows the average time spent in travel to grocery shopping on an average day by level of access to the nearest supermarket. The table shows the average minutes spent traveling to grocery stores for shoppers who lived in low-income areas with low, medium, and high access to supermarkets. These averages are compared with the national average. Overall, the national average of time spent traveling, one-way, to the grocery store was 15 minutes, and about 14 percent of the population traveled to the grocery store on an average day.

Time spent traveling to the grocery store was greater in low-income areas with low-access. The average time spent traveling to the grocery store for those who lived in these areas, 19.5 minutes, was significantly greater than the average time spent traveling to the grocery store for those in low-income areas with high access (15.5 minutes) and for those in low-income areas with medium access (14.1 minutes). In addition, those in low-access areas shopped less frequently—on average once every 8 days versus a national average of once every 7 days.

The difference in average time spent traveling to the grocery store by access level may not be surprising given that this study's definition of access is based on distance, and that, all else equal, it is expected that those who live more than 1 mile from a supermarket would spend more time traveling to the grocery store than those who live closer to the supermarket. To put these averages into context, table 3 also reports average time spent traveling to grocery stores by households in higher-income areas separately by their access levels. As expected, those with low access spend the most time traveling to the grocery store (19.5 minutes) compared with those who are closer. But the average of those in higher income areas that are more than a mile from a store is still almost 4 minutes shorter, 15.8 minutes, than the average time of those in low-income areas who are more than a mile from a grocery store.

The final set of averages shown in table 3 compares average time spent traveling to grocery stores for those with household income below 200 percent of Federal poverty guidelines and for those with income above 200 percent of poverty. Individuals with low income who live in low-income areas with low access spend about the same amount of time traveling to grocery stores (19.3 minutes) as those who do not have low income but who live in low-income areas with low access to grocery stores (20.5 minutes). Also included are national estimates for the 13 percent of the sample with missing income information.[13]

[13] Because household income is a sensitive question, it has a higher nonresponse rate than other CPS and ATUS questions.

Table 4 shows the mode of transportation used in getting to grocery stores. These results show that the majority of people who shopped for groceries drove to the store as either the driver of a vehicle or as a passenger with another household member. Those with low income and the lowest levels of access were the most likely to drive to the grocery store (93.3 percent, compared with 87.1 percent for medium-access shoppers and 65.3 percent for high access shoppers). Those who lived closest to grocery stores in low-income areas were more likely to walk or bicycle to the store than those in low- or medium-access areas (23.1 percent, compared with 2.2 and 5.4 percent for those with low and medium access). Very few shoppers used public transportation to get to a grocery store. Only 4.3 percent of shoppers in low-access areas got rides to the grocery store with nonhousehold members or in taxis, while 9.7 percent of shoppers in high-access areas got rides to grocery stores with nonhousehold members or in taxis.

Grocery shoppers from low-access low-income areas were more likely to have been accompanied by children on their trips to the grocery store than others—29.1 percent versus a national average of 22.8 percent. Having children along on the trip is likely to make the trip more cumbersome, making travel and grocery shopping more difficult for these low-access shoppers.[14]

The last rows in table 4 show whether grocery shoppers travel to grocery shopping from home or from work, and their trip chaining patterns. For about 8 percent of the shoppers, the time distance between work and the grocery store was shorter than between home and the grocery store. Interestingly, those in low-income areas with low access were the most likely to use work as an anchor location for grocery shopping, either traveling directly between the workplace and grocery shopping, or traveling between work and grocery shopping bunched with other activities (7.7 percent directly from work and 3.6 percent bunched with other activities from work). Those from low-income areas that had medium or high levels of access were less likely to access grocery stores from work. These estimates indicate that some of those who live in low-income areas with low access choose grocery stores closer to work than to home (11.3 percent). It is then possible that employment is providing these individuals with a food environment that is not a food desert, that is, that their job is in a neighborhood with a supermarket.[15]

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[14] Although we look only at "whom with" for the travel to and from grocery shopping, and not the whom with during the grocery shopping itself, Wiig and Smith (2009) found that when adults accompanied by children grocery shopped, that children influenced what food was purchased, particularly snack foods, frequently resulting in higher grocery bills.

[15] Both Bitler and Haider (2011) and Sallis and Glanz (2009) discuss the importance of including workplace as a food environment. Bitler and Haider state:"Healthy and nutritious food must be geographically close enough to a consumer to be useful. A precise characterization of proximity is unlikely to be fixed, either across region or within region, because proximity is affected by factors such as transportation availability (e.g., access to private or public transportation and congestion) and individual travel patterns (e.g., the relative location of one's residence and workplace). If the analyst only considers stores near where individuals live, then important food sources may be missed, such as those near where people work or near their children's schools." (pp. 155-156)

Table 3
Average time spent in travel to grocery shopping on an average day by access to grocery stores

		Average minutes travel time to grocery shopping, for those who grocery shopped		Average engaged in travel related to grocery shopping (on ave. day) in %	90% confidence intervals			
					minimum	maximum	minimum	maximum
	N		N		Average minutes		Average %	
Total population, age 15+, 2003-07	8,305	15.0	52,677	14.0	14.67	15.25	13.70	14.31
				Low-income areas				
Low access	573	19.5	4,387	12.1	18.06	20.93	11.06	13.12
Medium access	719	14.1	4,637	13.5	12.96	15.14	12.46	14.47
High access	610	15.5	4,180	12.3	14.34	16.66	11.28	13.39
				Not-low-income areas				
Low access	1,787	15.8	11,277	14.4	15.22	16.47	13.67	15.09
Medium access	2,141	12.5	12,707	14.7	12.09	12.94	14.08	15.33
High access	1,182	13.3	6,393	16.3	12.58	14.05	15.35	17.32
				Income, 2003-07				
Household income ≤ 200 poverty threshold	2,310	15.8	15,534	13.6	15.28	16.36	13.03	14.16
				Low-income areas				
Low access	286	19.3	2,107	13.6	17.32	21.27	12.15	15.14
Medium access	373	14.2	2,358	13.4	13.13	15.27	12.00	14.70
High access	307	16.4	2,185	12.5	14.57	18.15	10.97	14.04
				Not-low-income areas				
Low access	348	16.3	2,258	14.7	15.03	17.61	13.16	16.25
Medium access	403	13.6	2,562	13.3	12.55	14.69	11.98	14.61
High access	226	12.3	1,303	16.7	11.09	13.57	14.57	18.80
Household income > 200 poverty threshold	4,886	14.2	29,988	14.2	13.85	14.60	13.81	14.66
				Low-income areas				
Low access	207	20.5	1,624	11.3	18.33	22.60	9.83	12.79
Medium access	272	12.1	1,687	14.1	10.86	13.35	12.32	15.81
High access	216	13.5	1,375	12.6	11.86	15.15	10.91	14.35
				Not-low-income areas				
Low access	1,195	15.6	7,498	14.3	14.77	16.37	13.39	15.17
Medium access	1,470	11.8	8,480	15.0	11.36	12.33	14.20	15.89
High access	789	13.4	4,187	16.3	12.34	14.43	15.11	17.56

Table 3 Cont.
Average time spent in travel to grocery shopping on an average day by access to grocery stores

		Average minutes travel time to grocery shopping, for those who grocery shopped		Average engaged in travel related to grocery shopping (on ave. day) in %	90% confidence intervals			
					minimum	maximum	minimum	maximum
	N		N		Average minutes		Average %	
Income, 2003-07								
Household income missing	1,109	16.3	7,155	13.9	15.40	17.19	13.05	14.70
Low-income areas								
Low access	80	17.7	656	9.7	14.35	21.10	7.51	11.95
Medium access	74	19.4	592	12.3	14.46	24.38	9.64	14.87
High access	87	17.0	620	11.1	12.77	21.14	8.84	13.45
Not-low-income areas								
Low access	244	16.5	1,521	14.4	14.94	18.00	12.52	16.27
Medium access	268	14.4	1,665	15.0	12.90	15.81	13.14	16.88
High access	167	14.4	903	15.9	12.37	16.42	13.46	18.31

Note: Average time is one-way, not total travel time (based on shortest one-way time).
Source: 2003-2007 American Time Use Survey data; Current Population Survey sampling frame from Census Bureau; access levels based on 2000 Census of Population and a USDA ERS-compiled supermarket directory for the contiguous U.S. in 2006, own calculations.

Table 4
Characteristics of grocery shopping by level of access to supermarkets

		Low-income areas			Not-low-income areas		
	Total	Low access	Medium access	High access	Low access	Medium access	High access
				Mode of transportation in %			
Car, truck, motorcycle (driver or passenger w/hh member)	90.2	93.3	87.1	65.3	96.7	92.2	83.9
Walking or bicycle	4.8	2.2	5.4	23.1	0.3	3.1	10.0
Public transportation (bus, subway/train)	0.3	0.1	0.9	1.9	0.0	0.3	0.3
Other (passenger w/nonhh member, boat/ferry, taxi/limo, unspecified)	4.7	4.3	6.6	9.7	2.9	4.4	5.8
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0
				With whom in %			
Alone	48.8	40.0	39.0	40.8	49.9	52.7	53.6
With household members	42.1	49.2	49.9	46.1	41.1	39.5	37.9
With others, not household members	9.1	10.8	11.1	13.1	9.1	7.8	8.6
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0
With children (persons under 18 years old)	22.8	29.1	28.2	32.8	20.3	22.6	19.4
				Trip chaining in %			
Home to store, direct / Store to home direct	63.6	54.8	64.0	61.0	64.5	68.4	66.6
Home to store, bunched or clustered/ Store to home, bunched or clustered	28.4	33.9	31.1	34.9	26.5	25.8	26.3
Work to store, direct / Store to work direct	5.9	7.7	3.5	3.3	6.6	3.9	5.9
Work to store, bunched or clustered/ Store to work, bunched or clustered	2.1	3.6	1.3	0.8	2.5	1.9	1.3
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Note that "with whom" is for travel to grocery store, and not grocery shopping.
The person or persons with the respondent may only be present for part of the travel.
Characteristics are of one-way shortest travel time to/from grocery store.
Source: 2003-2007 American Time Use Survey data; Current Population Survey sampling frame from Census Bureau; access levels based on 2000 Census of Population and a USDA ERS-compiled supermarket directory for the contiguous U.S. in 2006, own calculations.

4.2 Travel time by access level and employment status

Tables 5 and 6 show travel times for those employed and those not employed, respectively. The main finding here is that average travel times for those employed are about the same as for those not employed. Although travel times were about the same, those employed and those not employed do have different participation rates of grocery shopping. On an average day over 2003-07, 13.1 percent of those employed grocery shopped, and 15.6 percent of those not employed grocery shopped. This is equivalent to those employed grocery shopping on average once every 7.6 days, and those not employed shopping once every 6.4 days, more than a one-day difference.

Table 5
Average time spent in travel to grocery shopping
on an average day by access to grocery stores for employed persons

					90% confidence intervals			
	N	Average minutes travel time to grocery shopping, for those who grocery shopped	N	Average engaged in travel related to grocery shopping (on ave.day) %	minimum	maximum	minimum	maximum
					Average minutes		Average %	
Total pop., age 15+, 2003-07	5,151	14.9	33,098	13.1	14.51	15.27	12.73	13.50
				Low-income areas				
Low access	303	21.2	2,398	10.8	19.18	23.23	9.60	12.03
Medium access	404	13.4	2,560	13.3	12.22	14.59	11.88	14.65
High access	336	15.2	2,341	11.7	13.49	16.89	10.32	13.01
				Not-low-income areas				
Low access	1,141	15.7	7,464	13.1	14.88	16.51	12.17	13.94
Medium access	1,361	12.7	8,312	13.4	12.14	13.32	12.62	14.16
High access	792	12.9	4,250	16.1	12.00	13.86	14.83	17.31
				Income, 2003-07				
Household Income ≤ 200 poverty threshold	1,082	15.2	7,372	12.6	14.42	15.93	11.81	13.36
				Low-income areas				
Low access	124	22.0	920	12.0	18.36	25.67	10.12	13.83
Medium access	181	12.8	1,054	14.4	11.37	14.16	12.27	16.60
High access	145	15.3	1,029	12.1	13.09	17.51	9.90	14.32
				Not-low-income areas				
Low access	156	15.5	1,128	11.7	13.74	17.23	9.63	13.71
Medium access	189	13.4	1,254	12.4	12.12	14.67	10.65	14.06
High access	112	11.3	641	16.1	9.83	12.75	13.04	19.20

Table 5 Cont.
Average time spent in travel to grocery shopping
on an average day by access to grocery stores for employed persons

					90% confidence intervals			
	N	Average minutes travel time to grocery shopping, for those who grocery shopped	N	Average engaged in travel related to grocery shopping (on ave.day) %	minimum	maximum	minimum	maximum
					Average minutes		Average %	
Income, 2003-07								
Household Income > 200 poverty threshold	3,431	14.3	21,743	13.2	13.85	14.85	12.68	13.65
Low-income areas								
Low access	137	21.2	1,143	10.8	18.84	23.59	8.93	12.58
Medium access	183	13.0	1,200	11.8	11.13	14.79	9.89	13.70
High access	152	14.1	1,004	11.5	11.78	16.47	9.73	13.22
Not-low-income areas								
Low access	838	15.4	5,444	13.2	14.41	16.35	12.25	14.25
Medium access	1,017	12.0	6,107	13.4	11.33	12.67	12.47	14.35
High access	579	13.0	3,084	16.1	11.73	14.21	14.62	17.49
Household Income missing	638	17.0	3,983	13.7		15.71	18.28	12.61
Low-income areas								
Low access	42	--	335	--	--	--	--	--
Medium access	40	--	306	--	--	--	--	--
High access	39	--	308	--	--	--	--	--
Not-low-income areas								
Low access	147	17.5	892	13.5	15.34	19.71	10.90	16.16
Medium access	155	15.9	951	14.5	13.70	18.03	12.10	16.89
High access	101	14.7	525	16.1	12.16	17.19	12.89	19.33

Note: Average time is one-way, not total travel time
(based on the shortest one-way time).
-- indicates that estimate is suppressed due to small cell size.
Source: 2003-2007 American Time Use Survey data; Current Population Survey sampling frame from Census Bureau; access levels based on 2000 Census of Population and a USDA ERS-compiled supermarket directory for the contiguous U.S. in 2006, own calculations.

Participation rates for those employed were lower than for those not employed for all subgroups. Employed persons in low-income, low-access areas had one of the lowest rates, 10.8 percent (equivalent to once every 9.2 days), versus 13.7 percent for those not employed in low-income low-access areas (equivalent to once every 7.3 days).

Table 6
Average time spent in travel to grocery shopping on an average day by access to grocery stores for not employed persons

		Average minutes travel time to grocery shopping, for those who grocery shopped		Average engaged in travel related to grocery shopping (on ave. day) %	90% confidence intervals			
					minimum	maximum	minimum	maximum
	N		N		Average minutes		Average %	
Total pop., age 15+, 2003-07	3,154	15.1	19,579	15.6	14.61	15.51	15.05	16.14
				Low-income areas				
Low access	270	17.7	1,989	13.7	16.15	19.34	12.02	15.47
Medium access	315	14.9	2,077	13.7	13.11	16.66	12.26	15.21
High access	274	15.9	1,839	13.3	14.09	17.70	11.50	15.09
				Not-low-income areas				
Low access	646	16.1	3,813	17.0	15.19	16.96	15.84	18.21
Medium access	780	12.2	4,395	17.3	11.51	12.86	16.04	18.55
High access	390	14.1	2,143	16.9	12.83	15.30	15.34	18.44
				Income, 2003-07				
Household Income ≤ 200 poverty threshold	1,228	16.4	8,162	14.6	15.61	17.14	13.79	15.45
				Low-income areas				
Low access	162	17.5	1,187	15.0	15.57	19.43	12.85	17.21
Medium access	192	15.7	1,304	12.4	14.07	17.36	10.78	13.98
High access	162	17.4	1,156	12.9	14.63	20.24	10.69	15.20
				Not-low-income areas				
Low access	192	16.9	1,130	18.1	15.12	18.71	15.54	20.58
Medium access	214	13.8	1,308	14.3	12.03	15.64	12.39	16.28
High access	114	13.4	662	17.3	11.73	15.09	14.26	20.36
Household Income > 200 poverty threshold	1,455	14.0	8,245	17.0	13.40	14.56	16.15	17.92
				Low-income areas				
Low access	70	18.9	481	12.7	14.42	23.35	9.53	15.84
Medium access	89	10.8	487	19.6	9.54	12.16	15.94	23.33
High access	64	12.2	371	16.0	10.01	14.38	11.37	20.70
				Not-low-income areas				
Low access	357	15.9	2,054	16.9	14.71	17.18	15.16	18.68
Medium access	453	11.6	2,373	19.2	10.87	12.26	17.42	20.95
High access	210	14.5	1,103	17.1	12.57	16.41	14.97	19.30

Table 6 Cont.
Average time spent in travel to grocery shopping
on an average day by access to grocery stores for not employed persons

	N	Average minutes travel time to grocery shopping, for those who grocery shopped	N	Average engaged in travel related to grocery shopping (on ave. day) %	90% confidence intervals			
					minimum	maximum	minimum	maximum
					Average minutes		Average %	
				Income, 2003-07				
Household Income missing	471	15.4	3,172	14.1	14.18	16.54	12.91	15.27
				Low-income areas				
Low access	38	--	321	--	--	--	--	--
Medium access	34	--	286	--	--	--	--	--
High access	48	--	312	--	--	--	--	--
				Not-low-income areas				
Low access	97	15.0	629	15.8	13.15	16.90	13.21	18.35
Medium access	113	12.3	714	15.8	10.58	14.04	13.09	18.46
High access	66	14.0	378	15.5	10.58	17.33	11.75	19.34

Note: Average time is one-way, not total travel time
(based on the shortest one-way time).
-- indicates that estimate is suppressed due to small cell size.
Source: 2003-2007 American Time Use Survey data; Current Population Survey sampling frame from Census Bureau; access levels based on 2000 Census of Population and a USDA ERS-compiled supermarket directory for the contiguous U.S. in 2006, own calculations.

Tables 7 and 8 show the characteristics of grocery shoppers who were employed and those not employed, respectively. As one might expect, a larger share of those employed drove (or were driven by a household member) to grocery shopping, 92.0 percent, versus 87.3 percent of those not employed, and a larger share of those employed traveled to grocery shopping alone, 50.5 percent versus 46.3 percent. Interestingly, a larger share of those employed had children with them when traveling to grocery shopping, 24.8 percent, versus only 19.8 percent of those not employed. Perhaps this is due to picking up/dropping off children to daycare before or after work, and consequently, on the way to grocery shopping. 13.5 percent of those employed who grocery shopped had a shorter travel time to/from their workplace than to/from home, that is, their workplace was the anchor for the trip.

Table 7
Characteristics of grocery shopping by level of access to supermarkets for employed persons

		Low-income areas			Not-low-income areas		
	Total	Low access	Medium access	High access	Low access	Medium access	High access
				Mode of transportation in %			
Car, truck, motorcycle (driver or passenger w/hh member)	92.0	97.4	89.9	69.9	97.7	92.9	85.8
Walking or bicycle	4.4	0.4	5.1	19.2	0.5	3.5	9.5
Public transportation (bus, subway/train)	0.1	0.0	0.9	0.2	0.0	0.1	0.1
Other (passenger w/nonhh member, boat/ferry, taxi/limo, unspecified)	3.4	2.2	4.1	10.7	1.8	3.5	4.7
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0
				With whom in %			
Alone	50.5	43.1	39.2	42.2	53.3	50.8	56.1
With household members	42.1	50.3	49.7	48.0	39.8	42.5	36.3
With others, not household members	7.4	6.5	11.1	9.8	6.9	6.7	7.6
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0
With children (persons under 18 years old)	24.8	30.7	30.2	32.8	23.2	25.7	19.3
				Trip chaining in %			
Home to store, direct / Store to home direct	58.7	39.6	62.6	56.8	61.9	63.6	61.8
Home to store, bunched or clustered/ Store to home, bunched or clustered	27.7	37.9	28.8	35.8	23.6	27.1	27.5
Work to store, direct / Store to work direct	9.8	15.4	6.2	5.9	10.5	6.4	8.8
Work to store, bunched or clustered/ Store to work, bunched or clustered	3.7	7.2	2.4	1.5	4.0	3.0	1.9
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Characteristics are of one-way shortest travel time to/from grocery store.
Note that "with whom" is for travel to/from grocery store, and not grocery shopping.
The person or persons with the respondent may only be present for part of the travel.
Source: 2003-2007 American Time Use Survey data; Current Population Survey sampling frame from Census Bureau; access levels based on 2000 Census of Population and a USDA ERS-compiled supermarket directory for the contiguous U.S. in 2006, own calculations.

Table 8
Characteristics of grocery shopping by level of access to supermarkets for not employed persons

		Low-income areas			Not-low-income areas		
	Total	Low access	Medium access	High access	Low access	Medium access	High access
				Mode of transportation in %			
Car, truck, motorcycle (driver or passenger w/hh member)	87.3	89.1	83.6	59.4	95.2	91.3	80.1
Walking or bicycle	5.3	4.2	5.9	28.0	0.1	2.4	11.1
Public transportation (bus, subway/train)	0.6	0.2	0.8	4.1	0.1	0.5	0.8
Other (passenger w/nonhh member, boat/ferry, taxi/limo, unspecified)	6.7	6.5	9.8	8.5	4.6	5.8	8.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0
				With whom in %			
Alone	46.3	36.8	38.8	39.0	44.7	55.7	48.6
With household members	42.0	48.1	50.2	43.6	43.0	34.9	40.9
With others, not household members	11.7	15.1	11.0	17.4	12.3	9.4	10.5
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0
With children (persons under 18 years old)	19.8	27.5	25.7	32.9	16.0	17.9	19.6
				Trip chaining in %			
Home to store, direct / Store to home direct	71.4	70.2	65.9	66.3	68.3	75.8	76.1
Home to store, bunched or clustered/ Store to home, bunched or clustered	28.2	29.8	34.1	33.7	30.9	23.7	23.9
Work to store, direct / Store to work direct	0.3	0.0	0.0	0.0	0.6	0.2	0.0
Work to store, bunched or clustered/ Store to work, bunched or clustered	0.1	0.0	0.0	0.0	0.1	0.2	0.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Characteristics are of one-way shortest travel time to grocery store.
Note that "with whom" is for travel to/from grocery store, and not grocery shopping.
The person or persons with the respondent may only be present for part of the travel.
Source: 2003-2007 American Time Use Survey data; Current Population Survey sampling frame from Census Bureau; access levels based on 2000 Census of Population and a USDA ERS-compiled supermarket directory for the contiguous U.S. in 2006, own calculations.

5 Conclusions

5.1 Limitations

We used the American Time Use Survey, which contains a one-day time diary. Because we have only one day, we miss inter-person variation since grocery shopping is an activity that is typically not done daily. However, we do have a large, nationally representative sample—a total of 72,922 completed interviews of which 11,726 respondents grocery shopped on their diary day—so we expect that any bias would be small.

With respect to our application to food deserts and travel time to grocery shopping, we do not know if the retail venue where the respondent purchased groceries was the nearest (either in time or geographical distance) grocery store to the respondent's residence, or even the preferred grocery store. We just know that the respondent purchased groceries on the diary day. This may lead to an overestimate of the travel time to grocery shopping if some respondents did not shop at the nearest grocery store.

In merging the access typology with the Census sample frames in order to analyze travel time by census tract access level and income level, some respondents could not be matched, either from the typology side (census tracts that could not be classified) or the respondent side (Census did not have the tract information in the sample frame). As a consequence, our sample was reduced to 8,305 respondents, still a large sample, however there is the risk that estimates calculated from the smaller sample are not the same as estimates calculated from the entire sample. This could result in either an over- or under-estimate of travel times.

5.2 Travel to grocery shopping estimates

Our findings on food deserts—low-income, low-access areas—are compelling. The travel time to grocery shopping, the time cost, was greater for those living in low-supermarket-access areas than for others. Not surprisingly, residents of food deserts grocery shopped less frequently, which would lessen the ability to have fresh produce in the household. In addition, they were more likely to be accompanied by children on their trip, which could make grocery shopping more cumbersome. Analysis looking at employment status found that travel times were about the same for those employed as for those not employed. However, the groups had different participation rates of grocery shopping and different travel characteristics, such that those employed shopped less frequently than those not employed.

Our findings of travel time to grocery shopping using nationally-representative data is an important contribution to the understanding of supermarket access in low-income areas. Not only travel times, but also participation rates—the percent who grocery shopped on an average day—were estimated, as well as whom the shopper was with and their mode of transportation. Having this information provides insights into possible difficulties that some subpopulations may have in purchasing healthy, nutritious food.

Most other food desert studies have looked at specific geographic areas, whereas we used nationally representative data. Whereas Rose and Richards (2004) study had data on travel time, they did not have a diary of the entire day and so could not analyze how individuals fit grocery shopping in their lives. Other food desert researchers have stated the importance of the time element in identifying and analyzing food deserts, however few studies have done so. Our measurement and analysis is a contribution in that it provides an additional dimension to the study of the extent of low access to supermarkets across the United States. This work compliments the food desert research that others have done looking at physical geographical distance.

5.3 Estimating travel times using time-use data

Our analysis of travel times in food deserts has provided a case study for analyzing travel using time use diaries. As discussed above, the existing literature is sparse on using time diaries to study travel times and patterns. Our methodology has contributed to the time use literature by providing a streamlined method of identifying and measuring travel time to a specific activity, in this case grocery shopping, using the American Time Use Survey data. Our methodology would work with other similarly-coded time use data. In addition, our technical detail and coding rules—no doubt tedious reading—provide time use researchers with information that may help understand the complexities of transforming time diary data into travel times. Time-use data, with detailed diary information and a wealth of demographic and labor force participation information, has much to offer in understanding individuals' travel patterns and the context for their trips, information relevant to a variety of policy issues. This methodology could be used for a variety of travel time research questions, allowing for estimates of travel time as the individual fits an activity into his/her life. We hope to see more researchers using time use data to analyze travel questions in the future.

This analysis also serves as an example to demonstrate the benefit from agencies' collaboration that allowed us to utilize confidential location information, even though we did not have access to it. Continued collaboration across agencies utilizing spatial information would benefit a variety of program and policy issues.

Appendix – Detailed coding rules

Missing where codes

We had to deal with the fact that the ATUS does not ask where a person was for personal care activities in the time diary, and so the where code is missing (TEWHERE=-1). Missing TEWHERE information was re-coded as at home (TEWHERE=1) if it corresponded to a personal care activity (0101xx, 0102xx, 0104xx) or a time when the respondent refused to provide an activity (500105) or did not remember his/her activity (500106) and if the activity was ad-

jacent to an at home activity. Similarly, if these missing TEWHERE conditions were met except the activity was adjacent to an activity done at one's workplace instead of one's home, then TEWHERE was re-coded as workplace (TEWHERE=2). We recoded TEWHERE as at home (TEWHERE=1) if the first two diary entries were Personal Care (01xxxx) and the third was travel.

Excluded diaries

If the respondent was not at home for any activity in the 24-hour time diary, then that observation was not included. If the mode of travel was by airplane, the observation was excluded as the grocery shopping was likely in an airport during out-of-town travel. For individual travel times that appeared unusual, the time diary was investigated to understand the story of the respondent's day. After investigation of these extreme travel times, thirty-seven observations with grocery shopping were excluded for the following reasons: (1) we determined that the respondent was out of town when the grocery shopping took place; (2) the time diary provided insufficient data, usually because the respondent reported "can't remember" or "none of your business" for portions of the diary day (ATUS activity codes 50xxxx); or (3) the respondent had a large number of errands or other activities on the diary day such that the total travel time to grocery shopping would likely be an overestimate of the time distance to the grocery store. The resulting dataset that we used to calculate the estimates contains 11,569 observations. A small number of extreme cases were included as they appeared as legitimate trips to/from grocery shopping—respondents who had zero minutes travel to grocery shopping, which is possible if the store is in the same building as the respondent's previous activity, and respondents who had 120 minutes or longer travel to grocery shopping.

Anchors

Home (TEWHERE=1) and workplace (TEWHERE=2).

Travel and travel time

We recoded activities '500101', '500103', '500104', '500107', or '509989' as travel (18xxxx) if the TEWHERE was a mode of transportation (TEWHERE=12-19, 21, 99).

Measuring the time to grocery shopping consists of adding all the travel legs (18xxxx) from home to store (070101 and TEWHERE=4,6,7,9,11) and from store to home. Then the "before store" time is compared with the "after store" time and the minimum is chosen. Note that if there is only one "side," that is, if the respondent has no activities at home before the store, or no activities at home after the store, then the one side is used as the trip length.

If the respondent reports being at his/her workplace, then the travel "counter" is reset, and the previous legs of travel are not included.

If the respondent grocery shopped two or more times, then the "before store" time is from home (or work) to the first occurrence of grocery shopping, and the "after store" is from the last occurrence of grocery shopping to home (or work).

Exclusions

Only observations with grocery shopping (070101) with the following TEWHERE codes are included: 4 (restaurant or bar), 6 (grocery store), 7 (other store/mall), 9 (outdoors away from home), and 11 (other place).

If "before store" or "after store" travel includes TEWHERE=20 (airplane travel), the observation is excluded.

Observations with no activity done at home on the diary day are excluded.

With whom—categories:

1. Alone: TUWHO_CODE= 18, 19

2. With household members: TUWHO_CODE= 20-30

3. With others (not household members): TUWHO_CODE= 40-58

These categories total 100%.

Separate category:

4. With child/ren (own child or other child): TUWHO_CODE=22, 27, 40, 52, 57 (for

TUWHO_CODE=22 and 27, and TEAGE<18)

With whom—Rules for multiple legs of travel:

If alone and then with someone (or vice versa), then code as with someone (either with household members or with others).

If with household members and with others, then code as with household members.

If alone and then accompanied by a child, then code as with child/ren.

Note: TUWHO_CODE rules for travel legs only, that is 18xxxx activities, not the dwell activities.

Mode of transportation—categories:

1. By vehicle, driver or passenger with household member—includes:

Driver (TEWHERE=12)

Passenger (TEWHERE=13) with household member during travel (18xxxx,

TUWHO_CODE is 20 - 30). This indicates access to a vehicle.

May include walking travel legs.

2. Walking only (all travel legs= 14), bicycle only (all travel legs=17).

3. Public transportation (TEWHERE= 15-bus, 16-subway/train, 18-boat/ferry), may include walking (TEWHERE=14) or biking (TEWHERE=17) travel leg(s).

4. Other—includes:

TEWHERE= 19 (taxi/limousine service) or 21 (other mode of travel)

TEWHERE= 13 (passenger in vehicle) if with nonhousehold member

TEWHERE= 99, unspecified mode of transportation

Note that observations with TEWHERE=20 (airplane) are excluded.

Rules for mode of transportation:

Ignore TEWHERE < 12 or TEWHERE > 30 (except TEWHERE=99, unspecified mode of transportation). There are some travel activities coded as TEWHERE=9 (outdoors away from home). This is likely to be the parking lot of the store.

If multiple legs of driving (TEWHERE=12) or riding (13) with a leg of walking (14), then code as By vehicle. (Example: Before store= 12, 14. After store= 14, 12.) In this case the walking involved is likely in the store parking lot.

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A conceptual typology of multitasking behavior and polychronicity preferences

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Abstract

This paper introduces a conceptual framework for the systematic analysis of multitasking behavior, and the corresponding degree of preference for doing multiple activities simultaneously (polychronicity). A typology of multitasking is developed along the two dimensions "share of time" and "share of resources" allocated to each task. We discuss the heterogeneous nature of resources and the importance of the time scale and time granularity used for measuring multitasking, among other considerations. An illustrative library of examples of multitasking situations is provided. Finally, we discuss the measurement of polychronicity as a time- and context-dependent vector, rather than as a single score.

JEL-Codes: Z13, J22, J24, C81, C83, O33, D03, D24, D61

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1 Introduction

Multitasking (or "doing more than one thing[1] at a time") is a virtually ubiquitous phenomenon of modern life. The impact of multitasking appears to be growing more pervasive (some would say invasive) over time, as a result of evolving lifestyles (and "workstyles") entailing greater spatial and temporal fragmentation (Couclelis, 2004) and schedules that call for increased productivity and faster execution of multiple tasks. Moreover, increased opportunities for multitasking are allowed, and increasingly organized through complex networks, by the availability of information and communication technology (ICT) applications and easier access to media content.

As common as multitasking is, however, many gaps remain in our understanding of the rationale behind its adoption and its implications. At the very core of the matter, the definition of multitasking often comprises several apparently different manifestations, and there is no universal agreement about what eventually can, and what cannot, be considered multitasking. For example, many scholars define both *simultaneously-conducted activities* and *switching between activities* as multitasking, while some (e.g. Arndt *et al.*, 2006) reserve the term to mean only simultaneously-conducted activities, and others (e.g. Delbridge, 2000) define it in terms of switching.

Whereas "multitasking" is a common entry in the popular lexicon, its more scholarly relative, "polychronicity", is less familiar. Polychronicity, often defined as "the extent to which people prefer to engage in two or more tasks or events simultaneously" (Kaufman-Scarborough and Lindquist, 1999a, p. 288), has been the subject of scientific study since at least 1959, when the anthropologist Edward T. Hall first discussed the use of time and the individual's involvement in activities in a cultural dimension. This is contrasted to "monochronicity" (or "monochronism"), or a preference for "doing one thing at a time"[2] (Hall, 1959, p. 178).

Although polychronicity and multitasking are sometimes used interchangeably (even within a single study), in this study we adopt the logical distinction suggested by Persing (1999) and Waller (2007), and further refined by König and Waller (2010) as well as Poposki and Oswald (2010). Specifically, we use "multitasking" to refer to the *behavior* of conducting more than one activity at the same time, and "polychronicity" to mean the *degree of preference* for such behavior (with natural counterparts "monotasking" and "monochronicity").

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1 The "thing" in question tends to be referred to as a "task" (hence, "multi*tasking*") in the human (work) performance literature, and as an "activity" in the time use literature. This paper will use both terms more or less interchangeably.

2 Hall actually used the term to refer to the behavior ("doing one thing at a time") rather than to the preference for such a behavior, but see our distinction in the following paragraph.

Researchers have devoted substantial effort to the study of multitasking as an increasing cultural phenomenon, and of polychronicity as a preferred lifestyle. The field of study is very much still evolving, with several scholars recently initiating a discussion of key conceptual issues related to polychronicity and multitasking. Among these, Kenyon (2010) identifies considerable variety in how the concept of multitasking is defined and measured in time-use diaries, and interpreted by those who complete the diaries. König and Waller (2010) and Poposki and Oswald (2010) likewise point to the multiplicity of definitions and measures of polychronicity. All of these works note that such conceptual ambiguities hamper our ability to conduct and synthesize research in this field.

Another problematic issue is the *time scale* on which activities and preferences are measured. Although the time scale is often discussed as a concern (Bluedorn *et al.*, 1992; Kenyon, 2010; König and Waller, 2010), the empirical research on this topic remains unsettled. For instance, the unit of time over which tasks are being considered remains completely unspecified in many studies (in particular, it is unspecified in all of the standard scales used to measure polychronicity; see Section 7 for brief descriptions of these scales). This approach leaves it to (1) the respondents to choose a unit, which may vary from one question to the next in a way unpredictable for the analyst; (2) the analyst to apply an assumption of what unit people have in mind, which may lead to ambiguities in interpretation (König and Waller, 2010); and (3) the audience of the study to apply a unit of its choosing. Further, as a projection of our own experience, we are convinced (cf. König and Waller, 2010, and also the distinction between micro- and macro-multitasking in Wallis, 2010, p. 10) that the same actors may exhibit different behaviors (and preferences) depending on the time scale on which activities are measured and recorded (as well as depending on the context and typology of activities in a specific study).

This paper continues and expands the discussion of some of the issues mentioned above, as part of an ongoing effort to more systematically map the conceptual landscape comprising the varied manifestations of multitasking and polychronicity. In the same way in which a physical landscape can be fundamentally characterized by the three spatial dimensions (length, width, and height) and by many other variables of interest (percent forest cover, lane-miles of roadway, land use type, population ethnicity, and so on), we examine our conceptual landscape from several different perspectives.

The first part of the paper addresses the two fundamental dimensions of the multitasking/ polychronicity landscape, namely the *share of resources* and the *share of time* allocated to the execution of activities, and attempts to clarify some ambiguities surrounding those concepts: in Section 2 we present a basic typology of multitasking based on those two dimensions, while the next two sections elaborate further on each of them respectively. Section 3 discusses the heterogeneity and allocation synergies of the available resources, as well as the interactions among activities and the concept of output efficiency. Section 4 addresses the important role of time in describing multitasking scenarios, both in terms of the *granularity* with which

we measure the time assigned to each activity, and of the time *horizon* against which multitasking is assessed.

The latter part of the paper builds on the earlier concepts to further flesh out useful ways of categorizing various types of multitasking/ polychronicity. Sections 5 and 6 focus on content- or nature-based relationships between two (or more) activities done "at once" (as opposed to the structural relationships based on the resource and time dimensions). In particular, Section 5 discusses the designations of activities as "primary" versus "secondary" and as "active" versus "passive", and the special nature of "travel" and "waiting" as (often) transitional activities. In Section 6, we present and discuss a table of illustrative examples of possible combinations of key features (primary versus secondary, active versus passive, and purpose of each activity), demonstrating the great diversity of the multitasking landscape.

Section 7 turns to the important perspective of the individual actor: how s/he feels and behaves with respect to conducting multiple activities at once. We explore what it means to be polychronic, and propose that an individual's polychronicity can in principle be characterized by a *vector* or *profile* of preferences rather than by a single *score*. Finally, Section 8 offers some concluding remarks on the topics discussed in the paper, including the proposal of a number of directions for future research.

The goals of this paper are (1) to support future data collection efforts by pointing to ways in which the concepts and behaviors of interest to a particular study can be more precisely articulated and measured; and (2) by expanding the characterization of multitasking, to generate more sophisticated analyses of its nature and consequences. For example, our conceptualization lends itself to the analysis of a number of research questions of practical and policy importance, such as whether multitasking increases productivity, how the concept of efficiency could be operationalized, and the circumstances under which multitasking may increase or decrease stress and well-being. In sum, we hope that this discussion will provide a useful framework on which to build future empirical research that increases the understanding of this broad-based phenomenon and its implications for the decisions of daily life.

2 A two-dimensional typology of multitasking

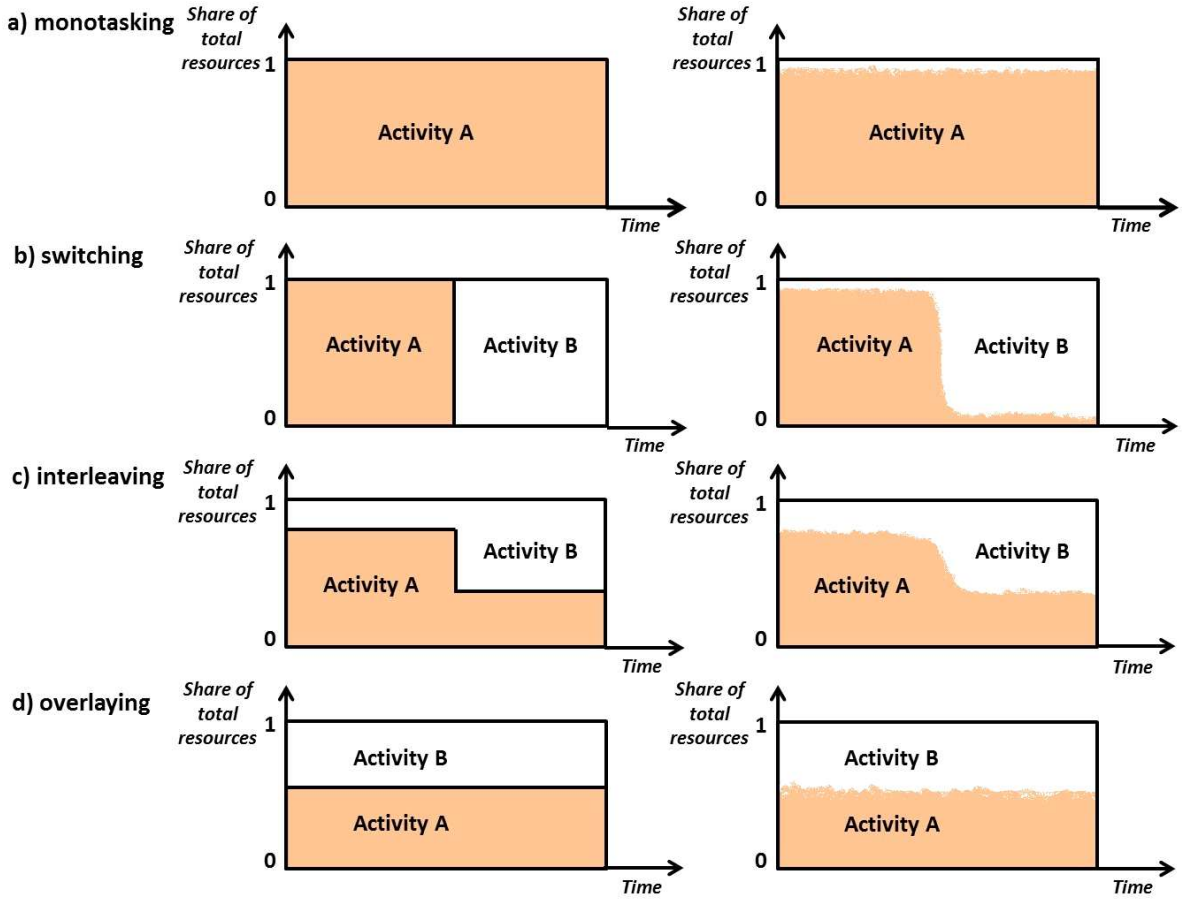
What does it mean to conduct multiple activities "at the same time"? For simplicity of exposition, we initially assume that at most two tasks are involved at any given point in time.[3] The literature commonly identifies two ways in which "multiple activities at the same time" can occur (Bluedorn *et al*., 1992; Kaufman *et al*., 1991; Salvucci *et al*., 2009): *sequentially* (*switched, alternated, interleaved, intermittent*) or *simultaneously* (*concurrently, overlaid*). In the parlance of network analysis, these two ways respectively correspond to *series* and *paral-*

[3] In reality, of course, more than two tasks can be underway "at the same time", and some of our later discussion addresses this explicitly.

lel flows or processing (Wickens, 2007, pp. 245-246). In this study, we only briefly consider a third way to organize tasks (Mokhtarian *et al.*, 2006), in which a single activity may simultaneously fulfill two purposes[4], such as when clothes shopping is both a household maintenance and a leisure activity for some people.

Starting from the definitions in the literature, we believe it is useful to further distinguish two forms of sequential engagement (Figure 1).

Figure 1
Types of multitasking (left: "archetypical" examples; right: "real-life" typical examples)



Source: Own illustration

[4] This concept of one activity fulfilling two purposes at the same time is not usually considered to be multitasking, although the example of Kaufman *et al.* (1991), of combining a family visit with a vacation, could be one exception in the literature. However, from the standpoint of efficiency in time allocation and preference/need fulfillment, such a case can function similarly to the others. For example, if an individual desires both a certain amount of work and a certain amount of leisure in a time span too short to accommodate both desires sequentially, she could either overlay one on top of the other, trying to do different work and leisure activities simultaneously, or she may be able to satisfy both desires by engaging in a work activity that also serves a leisure function (Csikszentmihalyi and LeFevre, 1989; Lewis, 2003). The common phrase "killing two birds with one stone" refers to the latter type of scenario; not very different in concept from the "doing two things at the same time" idea of conventional multitasking. We further discuss the blurry boundary between these types in Sections 5 and 6 and in Appendix B.

Consistently with findings from clinical research on brain activities (Charron *et al*., 2009), we use the term *"switching"* to refer to a rigid, dichotomous engagement: alternation between activities, but with only one activity carried out at a time. The first activity is "switched off" when turning to the second activity, and vice versa. An analogy from the world of computer processing would be *closing a software application before running another computer program*: reloading the first application at a later point will take some extra time, while in the meantime all resources are assigned to the execution of the second program.

We use *"interleaving"* to refer to a softer type of alternation, in which one activity claims most resources, while another remains in the background. The individual alternates between which activity is "in the forefront" but both continue to operate simultaneously at some level. This case corresponds, in the computer processing analogy, to *an application that is reduced to an icon (but is still running) while a second software application is launched.* The first application is still loaded in memory, and it keeps using some of the available resources. When needed, re-switching to this application can be done rather rapidly.

The descriptions above are consistent with recent findings on the capacity of the human mind to resume activities after an interruption (either expected or unexpected) and its ability to put activities "on hold" for a faster resume at a later time (Salvucci *et al*., 2009). In particular, the literature (e.g. Kiesel *et al.*, 2010) distinguishes between *switching costs* (reaction time and error rates are higher if the individual is required to switch between two tasks within a given block of time than if only a single task is involved in a given block) and *mixing costs* (reaction time and error rates are even higher when switching between tasks is more frequent or more unpredictable). The interpretation of the latter is that when switching is frequent or random, some resources are devoted to the background task, in anticipation of an upcoming switch, while conducting the foreground task.

The left part of Figure 1 illustrates prototypical examples of resource allocation to different tasks over time, starting (part a) from the "degenerate case" in which the individual conducts only a single activity (complete *absence* of any multitasking, or "monotasking"). The remaining parts of the figure show the allocation of the individual's resources in the cases of *switching*, *interleaving* and *overlaying* activities. For each rectangle, the horizontal axis measures the elapsed time during which the activities are performed. The vertical axis measures the share of total resources that are dedicated to each activity, with the maximum level shown in the figure representing the total amount of available resources that could be allocated for the contemporaneous execution of all activities. For simplicity of exposition, we initially treat "resources" (i.e. a quantified composite of the physical and mental *energy* required to conduct activities) as *homogeneous*, *fixed* in quantity and *completely fungible* between activities. We relax these assumptions in Section 3, when we discuss the allocation of resources belonging to multiple "domains" (e.g. physical vs. mental) in a multidimensional framework for allocation of resources to the execution of activities.

The left part of Figure 1 presents "crisp" archetypes of each form of multitasking, which can be considered "ideal" or extreme reference cases. In reality, task switching never happens in a perfectly *sharp* way, with instantaneous switching from the execution of one activity to the other or with absolutely all resources devoted to a single task. Accordingly, the right-hand panel of Figure 1 illustrates a "fuzzier" and more realistic environment, in which (1) the share of resources allocated exhibits microscale fluctuations over time among the two activities carried out "at the same time", and (2) a residual share of resources is usually constantly "busy" for the execution of basic needs and tasks that are run "in the background" (Haroush *et al*., 2009). From this point of view, neither "pure switching" nor "pure monotasking" really exists in the context of full consideration of all activities undertaken by an individual. However, in certain specialized contexts, e.g. if a researcher wished to examine only a subset of activities (such as leisure-time hobbies) over a certain length of time (e.g. during a half-day), one could imagine monotasking in the sense that only one such activity might be conducted during that time, and switching in the sense that one could fully disengage from one activity (e.g. woodworking) before turning to another activity (e.g. knitting) for the remainder of the observed half-day.[5]

As indicated, the four types of multitasking shown in Figure 1 differ along two dimensions, the *share of resources* (r_{A1}) allocated to an activity A (vertical dimension) and the *share of time* (T_1) during which the initial configuration associated with that share of resources is maintained before moving to a new configuration (r_{A2}).[6] A more complete discussion of the relationships between these four basic archetypes of *monotasking*/ *multitasking* is presented in Appendix A, where we discuss how each one of the cases presented in Figure 1 can metamorphosize to the others by varying the two dimensions of *disparity in the allocation of resources* and *share of time*.

By comparison, several researchers refer to a *one-dimensional* continuum of multitasking[7]. For example, Salvucci *et al.* (2009) consider the relevant dimension to be the time taken to switch between activities, where concurrent activities occupy one end of the spectrum (very short time between switching) and sequential activities the other (long time between switching, presumably fading to monotasking at "very" long times). As we discuss later, however, some sets of activities can be completely overlaid at even the smallest meaningful unit of time

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5 Even there, however, it could be relevant to consider the "seepage" of non-leisure-time-hobby activities into the time allocated to hobbies (i.e. the execution of other tasks in the background, or their intrusion into the foreground), as well as leakage between hobbies (thinking about one while conducting another).

6 We here refer to the basic situation in which all available resources are allocated to the two possible activities *A* and *B* so that $r_{Ai} + r_{Bi} = 1$ at all times t_i. Of course, activity B could be "doing nothing", with r_{Bi} representing the share of idle resources, i.e. not allocated to the execution of any activities during time t_i.

7 Or polychronicity: Madjar & Oldham (2006, p. 120) refer to a "continuum of preferences", with monotasking at one extreme, simultaneous overlay at the other, and switching in between. Hecht and Allen (2005, p. 157) similarly refer to a continuum, with monochronicity at one end, simultaneity at the other, and mixed preferences and/or switching in between.

(as well as at larger units – both of which are precluded in the Salvucci *et al*. continuum), and so the expectation that "switching" is necessary seems to us to be unduly restrictive in conceptualizing the entire space of multitasking possibilities. Multiple activities can be completely overlaid precisely when they can (1) simultaneously share the same resources, or (2) call on different types of resources (Section 3), and so we believe that the two-dimensional characterization, taking resource allocation into account, allows for a richer and more complete conceptualization. As can be seen in Figure 10 of Appendix A, the intermediate concept of interleaving, in which resources are *simultaneously* allocated to multiple tasks, is literally pivotal to this characterization. We are not aware of any prior explicit characterizations of the multitasking landscape as a *two-dimensional* space.

For the purposes of the present discussion, the height of the rectangle has represented the "total resources" that are available to an individual, and the length has represented one unit of time in which activities are observed (period of *time of observation*). In the following two sections, we further elaborate on each of these two dimensions, respectively.

3 The resource dimension

Section 2 introduced the classification of multitasking based on the two dimensions of "share of resources" and "share of time". In this section, we first elaborate in greater detail the nature of the resources, or *inputs*, that can be allocated for the execution of activities, and how an individual may have access to different domains of resources that are often not perfectly tradable (or "substitutable") across tasks. Then, we turn to a general discussion of possible *outputs* from these tasks. That is, we consider how resource inputs are combined to complete one or (usually) more tasks, resulting in a measure of productivity, or *performance*, of the activities that are conducted "at the same time".

3.1 The inputs – Resource heterogeneity and allocation synergies

In Section 2, for expositional simplicity we treated "resources" as rigidly bounded, additive and completely fungible across tasks (i.e. trading resources among tasks represents a zero-sum game). Under this assumption, the total amount of resources (total *inputs*, borrowing terminology from economic production theory) allocated to the execution of activity A during time *T*, in either a multitasking or monotasking configuration, is equal to the solid-colored area located under the function r_A, as represented in Figure 1. The remaining resources (the white area above the r_A "curve") are allocated to activity B (assuming that all resources are fully allocated to the activities A and B at all times, i.e. $r_B = 1 - r_A$).[8]

[8] More realistically, a variable portion of the available resources often remains "idle" during the execution of one or more activities, as it is rather difficult to be always under the condition of perfect allocation of the available resources ($r_A + r_B = 1$ at all times). In the case of monotasking, in particular, the quantity $1 - r_A$

In a more general case, in which the allocation of resources is regulated by the continuous functions $r_A(t)$ and $r_B(t)$, the total amounts of resources allocated to activities A and B respectively become:

(1) $$R_A = \int_0^T r_A(t)dt$$

and

(2) $$R_B = \int_0^T r_B(t)dt$$

with

(3) $$R_A + R_B = R_{tot} = 1.$$

The empirical reality, however, is often more complex: the total resources available to an individual for the execution of tasks usually comprise different dimensions or *domains* of resources (e.g. mental versus physical), which can be allocated in combinations specific to each task. Furthermore, the impact of the execution of one task on the allocation of resources to another task varies depending on whether the two tasks use resources belonging to the same domain (and therefore "compete" for the allocation of the same resources) or different domains.

In his now-classic Multiple Resource Theory in human factors, Wickens (2008) identifies four domains along which resources can differ: *stage* (perception/cognition versus response), *code* (spatial versus verbal), *modality* (visual versus auditory, and potentially versus tactile), and *channel* (focal versus ambient). Consistent with some portions of the sizable dual-task performance literature (e.g., DiDomenico and Nussbaum, 2008 and McCulloch *et al.*, 2009), we treat the "mental" versus "physical" as a fifth such domain.[9] To the extent that multiple tasks tap different combinations of these five domains, they may be more readily conducted simultaneously. Even when a single domain is involved, there may be substantive differences within that domain that permit smooth combinations: walking and talking, for example, would both be considered physical, response activities (though talking also requires conscious mental activity, unlike walking in most cases), but involve very different physical movements and thus can usually easily be combined. On the other hand, talking while playing a challenging musical instrument could be very difficult because both activities compete for mental as well as physical resources. Such combinations *are* possible, however: for example, Krampe *et al.*

identifies the portion of the individual's resources that is not allocated to the execution of the single activity A, and therefore remains "idle".

[9] Perhaps because of his concentration on occupations such as pilot or air traffic controller, the physical domain is not prominent in Wickens' work. It may correspond approximately to his response dimension, with the inclusion of vocal response as a physical act.

(2000) note that highly-skilled pianists can essentially control both hands simultaneously but separately.[10]

Similarly, juggling numerous objects of different sizes, shapes, and weights (while talking to the audience) is a skill learned only after a great deal of practice. Accordingly, the literature (e.g. Iqbal *et al.*, 2010) also points out that the more automatic or routine the tasks are, the easier it is to conduct them simultaneously. Along these lines, Hallowell (2006, p. 49) distinguishes between tasks controlled by the cerebellum (the "automatic pilot of the brain"), which after substantial practice makes them "effortless", and those requiring the conscious decision-making action of the frontal lobes of the brain. Thus, the "remaining amount of resources" available for a second task after allocation to the first task could be quite variable, depending on the extent to which the second task resembles (and therefore conflicts with) the first, and the extent to which the actions involved are habitual or routine.

To reflect the fact that distinct resource domains *may not* be completely interchangeable, we now conceptualize the total amount of resources as an *n*-dimensional vector or "constellation" (Iqbal *et al.*, 2010, p. 1289), $\vec{R}$, whose i^{th} element, D_i, denotes the amount of resources available from domain i $(i = 1, 2, \ldots n)$.[11] For instance, if $n = 2$, in the case of a two-dimensional space of resources, D_1 and D_2 could respectively represent the amounts of available physical and mental resources[12] (alternatively, they could represent the amounts of resources available from the cerebellum and from the frontal lobes of the brain, respectively).

Any single activity may draw on any or all of the available resource domains, and multiple simultaneous activities are possible to the extent that their combined domain-specific requirements do not exceed the total domain-specific resources available. For illustrative purposes, Figure 2 represents the possible space of the allocation of resources over time in the

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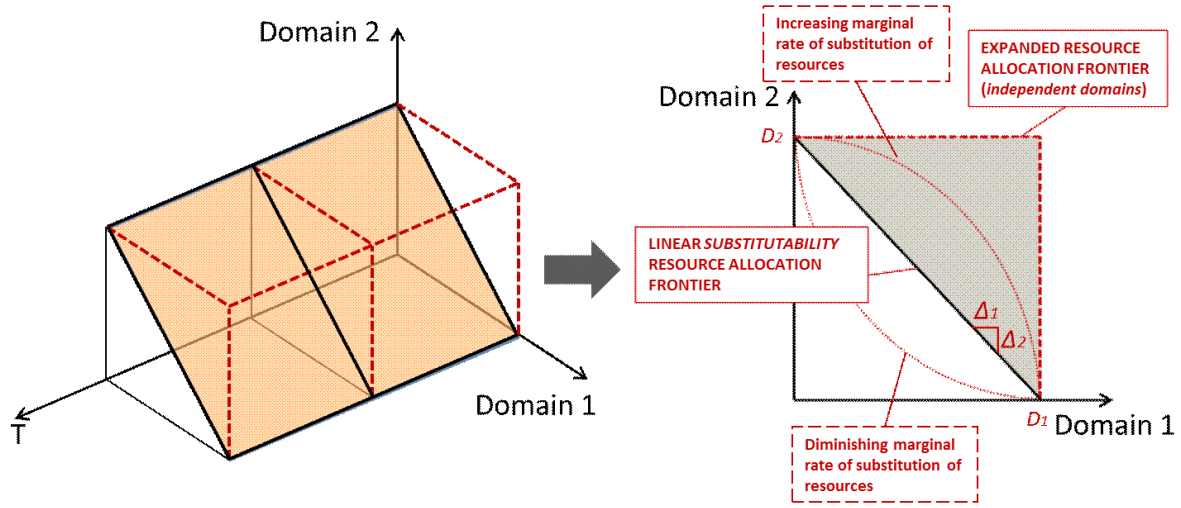
[10] The colloquial term "muscle memory" refers to such cases, where intense practice results in such familiarity with a task that "the muscles do it from memory", and therefore the task requires a reduced amount of the mental resources that were necessary before it became more routine.

[11] With this attempt to operationalize the vectoral concept, we suggest that several of the four domains described by Wickens are actually pairs of distinct domains. For example, "visual" and "auditory" do not seem to be labeled extremes of a single dimension, but rather different dimensions (and similarly for "physical" and "mental", although, as discussed earlier, Wickens does not include these dimensions). One possible exception is the focal/ambient domain, which could be viewed as corresponding to degrees of attention/centrality. However, similar to the situation with time as discussed in Section 4, there can be different degrees of granularity with respect to resource domains as well, and for some purposes, a coarse granularity may serve. At the finest granularity, as long as the resources in question are internal to the individual (as discussed in passing in Section 5.2, in some instances external resources may be relevant), the distinction between different domains must be a neurophysiological one, associated with what portions of the body can and cannot be volitionally used simultaneously.

[12] Of course, real-life constraints may sometimes limit the availability of one (or more) domain(s) of resources, such that not all resources belonging to that domain can be allocated. For instance, the presence of a physical or mental impairment may reduce the availability of a specific kind of resource for an individual. In this case, the execution of tasks that require that type of resource will be limited by the presence of this additional limitation (this can be graphically represented by a reduction of the available amount of resources D_i to a level $D'_i < D_i$ in one or more domains).

case of only two orthogonal domains. More complex situations can be conceived in hyper-spaces in which multiple domains of resources are allocated.

Figure 2
(left) Space of the available resources belonging to two orthogonal domains; (right) Time slice through the left-side figure – Possible frontiers for the allocation of resources in a two-dimensional space (two separately-operable or substitutable domains of resources)



Source: Own illustration.

The shaded area in the left part of Figure 2 represents an example of the frontier that delimits the possible configurations in the allocation of resources belonging to the two domains. All combinations (d_1,d_2) delimited by (i.e. "under") this frontier curve represent possible configurations for the allocation of these limited resources, in which the available resources are completely (at the limit, on the frontier curve) or partially (under the curve) allocated. The left part of Figure 2 identifies the resource allocation frontier when the two resource domains are perfectly linearly *substitutable*. In this situation, the resources from the two domains can be easily traded/substituted. This represents the special case in which all resources actually belong to just one domain, with all activities competing for the allocation of this unique set of resources. All combinations of resources with $r = d_1+d_2 = const$ on the allocation frontier represent possible configurations of the resource allocations for the execution of tasks.

But different allocation frontiers are possible, depending on the way the resources belonging to the two domains interact. The right part of Figure 2 expands the concept that has been just introduced, with the representation of several possible resource allocation frontiers at a generic time *t* (obtained as the section of the three-dimensional space on the left part of the figure at time *t*). Under the substitutability assumption just described, the possible resource allocation configurations are limited by the diagonal-line resource allocation frontier. On this frontier, any increase $\Delta_2 > 0$ in the use of the resource from one domain always generates a reduction $\Delta_1 < 0$ in the resources from the other domain, or conversely, a reduction in the use of resources from one domain allows for an increase in the other.

The more the allocation frontier departs from the diagonal (right part of Figure 2), the more that the way the individual can allocate his resources to the execution of activities differs from the simple case of perfectly tradable resources (inputs). The allocation of resources can expand beyond this boundary (diagonal) in the case of the use of different (and positively complementary) domains of resources.[13] For example, D_1 and D_2 may denote the total amount of physical and mental resources in the case of "walking while talking": an individual who performs physical activities while being involved in an intense conversation with a colleague contemporaneously executes activities that use resources belonging to different domains; the execution of the "mental" activity enables the complete allocation of the individual's mental resources that otherwise would remain "idle", without necessarily reducing the amount of physical resources (s)he can allocate to the activity "walking".

Resource allocation frontiers *above* the linear substitutability frontier (the diagonal) are associated with cases in which the contemporary allocation of resources from the different domains generates *positive synergies*. Using an analogy with terms from microeconomic theory (cf. Nicholson and Snyder, 2008), these types of resource frontiers would be associated with an *increasing Marginal Rate of Substitution* (MRS)[14], in which the allocation of resources from one domain tends to *facilitate* the allocation of resources from the other domain, thus expanding the space of possible configurations for the allocation of resources.[15] At the extreme, the resource allocation frontier can expand all the way up to the case of two *independent resources*: in this situation, the allocation of resources belonging to one domain does not affect at all the allocation of resources belonging to the other domain (they are treated as independent domains), so that the entire amounts D_1 and D_2 of available resources can be allocated.[16]

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[13] It is important to note that the allocation of the individual's resources may differ depending on the type of activities to perform, the context in which the individual has to perform them, his/her individual preferences and attitudes, and the experience and familiarity with the execution of the activities, as exemplified by the aforementioned example of "walking while talking".

[14] Although the concept of an increasing (or constant) marginal rate of substitution is unusual when defining the indifference curves for customers' utility in microeconomic theory, this idea makes sense when describing the allocation of resources allowed by different configurations of multitasking. In this case, the purpose of the quantitative approach is to discuss the possible resource allocations, subject to the limits represented by the different allocation frontiers (and not to define indifference curves as in consumer theory, or isoquants as in production theory). As a consequence, it is implied that the individual's utility might vary on these frontiers, and that she might reach higher levels of personal utility, if this is allowed by the constraints on the allocation of her resources, and if her utility increases with an increase in the contemporary allocation of resources to different tasks.

[15] Note that on the linear substitutability allocation frontier, i.e. the diagonal in the graph, the MRS is constant, as resources can be substituted in a linear way at any point on the frontier.

[16] In theory, the allocation of resources could happen even beyond this expanded resource allocation frontier, in the presence of *ultraefficient* synergies in the allocation of resources, which generate some *multiplying effects* in the use of resources. Imagine the case, for instance, in which the full allocation of mental resources might increase the availability of physical resources, for example, through identifying more ergonomic positions from which to lift heavy weights. Similarly, regular physical activity and provision of enough rest (both maintenance activities that involve the use of physical resources) are activities well-known to increase the mental capacities of an individual, *expanding* the space for the allocation of resources.

Particular interactions between resources belonging to two different domains, and among the tasks that use these resources as inputs, can also *limit* the capacity to contemporaneously deploy resources belonging to the two domains when performing more than one task. The resource allocation frontier associated with such *negative synergies*, which features a *diminishing* MRS, lies *below* the linear substitution allocation frontier (diagonal), as shown in Figure 2. The extreme "degenerate" case in this direction is the frontier curve that coincides with the two axes of the bidimensional space for the two resource domains. This degenerate case corresponds to total incompatibility in the contemporary allocation of the resources from the two domains: in this extreme situation, even if the individual has access to two resource domains, resources can be allocated only from one domain at a time. In this case, any reduction in the use of the resources belonging to one of the two domains will not increase the availability of resources belonging to the other domain at all, until the amount of resources used from the first domain is reduced to zero. At this point, the individual is able to allocate the resources available from the other domain.

Intermediate curves between the two extremes cover most real-life cases in which partial substitution among the domains is possible: an increase in the amount of resources consumed from one domain determines a decrease in the amount of resources that can be consumed from the other domain, with the shape and the slope of the substitution curves varying with the conditions under which the resource domains interact. Returning to the "talking while walking" example, if we increase the consumption of physical resources (increasing the walking pace) we will be still able to allocate mental resources to our conversation, although the availability of mental resources will diminish the more we increase our physical activity. The way the substitution of the resources may work depends on several variables, e.g. the overall physical condition of the individual, previous training and/or transient conditions of rest, tiredness or stress.

3.2 The outputs – Multitasking efficiency

One implication of the heterogeneity of resources is that the allocation of resources belonging to different domains may contribute to a perception of increased performance and/or efficiency of the individual. It is commonly stated that each person only has 24 hours a day, but in fact, some people may effectively accomplish "more than 24 hours' worth" of activities, due to their ability to conduct multiple tasks at once. For example, Kenyon and Lyons (2007) found that secondary activities added an average of nearly seven hours per person per day in their sample, a 46% "increase" in waking hours; Floro and Miles (2003) found increases of nearly 44% for women and 20% for men. This immediately raises at least three issues:

- *Relevance*: at least in many contexts of interest, such as studies of work productivity, we need to distinguish in some way between tasks that are relevant (whether positively or negatively influential) or irrelevant to the context (or create some other *relevance metric*). For example, the manager is not directly interested in the fact that her employee listened

to 20 hours' worth of music while working 35 hours – thereby accomplishing 55 hours' worth of activities while the company only had to pay him for 35! – she is interested in such information only to the extent that it affects her employee's productivity or job satisfaction.

- *Quantity vs. quality*: even if multitasking may contribute to an increase in the *quantity* of the output, how does it affect its *quality*? Suppose that, during an industrial engineering experiment, allowing an assembly line worker to listen to music while on the line is shown to increase her happiness and reduce her need for breaks and rest time, so that the number of widgets she produces increases by 10%, from 100 an hour to 110 per hour. If her defect rate doubles at the same time, the factory is not likely to consider it a net plus. This example relates to the level of *compatibility* in the execution of multiple activities at the same time, which is a function of the types of activities being performed and of the types of resources required by these activities.
- *Productivity*: not all multitasked activities interact with each other in the same way. For the sake of argument, suppose that an employee conducts two *relevant* activities within a given unit of time (through any of the forms of multitasking discussed in Section 2). What is the impact on her *productivity*? What is interesting is that even the *quantitative* impact is ambiguous, as well as the *qualitative* one. The conceptual possibilities for the *output* are similar to those discussed previously for the resource *inputs*. Specifically, the two activities may interact *negatively*, as when trying to do both things at once impairs the speed and/or quality with which one or both of them are accomplished. This is a typical situation that arises when two (or more) activities are competing for the allocation of resources belonging to the same domain[17]. In this case, one activity is distracting attention from the other, creating a "start-up overhead" (the switching and mixing resource costs mentioned in Section 2) when switching or interleaving between them (Salvucci *et al.*, 2009; Kiesel *et al*., 2010). Alternatively, in some cases, activities may interact *more efficiently*, as when interleaving between activities allows the brain to continue to work subconsciously on the background task, resulting in returning to that task with increased energy and/or creativity (e.g. Mark *et al.*, 2005).[18] Or, the two tasks may operate *independently*, with neutral impacts of one task on the other. To the extent that the employee's output can be assessed with a single metric, these situations correspond to the *whole being less than, greater than, or equal to the sum of the parts*, respectively (see Lyons and Urry, 2005 for a discussion of this point in connection with activities conducted while traveling).

[17] Negative interference can be also caused by the inability of the individual to control too many contemporaneous processes, even if they are predominantly using different resource domains.

[18] Sometimes even *super-efficiency* results, as when the work on one task directly provides inspiration that improves the other one (e.g. Hudson *et al*., 2002).

Let us formalize these concepts somewhat. We can express the total output associated with the execution of a generic activity A under conditions of monotasking as:[19]

$$O_A^{mono} = f(R_A \mid c, a, n_A, ..., etc.) \quad (4)$$

The output is a function of the resources (inputs) allocated to activity A, R_A, and of the specific conditions under which the activity is carried out: the context *c*, the individual's characteristics (or *abilities*) *a*, the nature (or *features*) of the activity n_A, and so on. If the same activity A is now performed under conditions of multitasking, the output generated by this activity will depend on the specific multitasking pattern:

$$O_A^{multi} = f(R_A \mid c, a, n_A, n_B, n_{AB}, R_B, ..., etc.) \quad (5)$$

How *efficiently* two activities can be carried out under conditions of multitasking depends on many factors: the nature of each activity *individually* (n_A and n_B), the features associated with that particular *combination* of activities (n_{AB}), the individual's skills, attitudes and preferences, and the shares of resources R_A and R_B (different types of multitasking, as presented in Figure 1, may be associated with different levels of efficiency for a specific individual).

For a specific multitasking configuration, we can therefore compute an *efficiency score* η as the ratio between the output obtained under conditions of multitasking and the output obtained under conditions of monotasking[20]:

$$\eta = \frac{O_A^{multi}}{O_A^{mono}} \quad (6)$$

Evidently, the efficiency score η can be smaller than, equal to, or larger than 1, depending on the effects that the specific multitasking configuration has on the output in comparison with the basic monotasking case (respectively decreasing, not affecting, or increasing the output in comparison with monotasking)[21].

In the more general case of continuous functions for the allocation of resources over time to two activities, $r_A(t)$ and $r_B(t)$, the previous functions become:

$$O_A^{mono} = \int_0^1 f(r_A(t) \mid c, a, n_A, ..., etc.)\, dt \quad (7)$$

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[19] Similarly to the previous distinction among multiple domains of resource inputs, output could also be characterized as a vector of various attributes (e.g. one or more measures of quantity, one or more measures of quality, other specific characteristics of the production, etc.). For simplicity, we restrict the current discussion to the case of a single measure of output.

[20] Perhaps unfortunately, in different contexts the same Greek letter η is used to symbolize two different economic concepts: efficiency, and elasticity. As we define it here, our use of the term "efficiency" and the symbol η is not associated with the economic term "elasticity" (the percentage change in the amount of output associated with a percentage change in the amount of inputs).

[21] In more elaborate applications, the efficiency score η could be represented by a vector of efficiency scores, to account for possible different components of output. This is the case for the assembly-line example (discussed above), where $\eta > 1$ for the indicator of output *quantity* (the number of widgets increased with multitasking), but $\eta < 1$ for the indicator of output *quality* (the defect rate became worse).

and

$$O_A^{multi} = \int_0^1 f(r_A(t) \mid c, a, n_A, n_B, n_{AB}, r_B(t), ..., etc.)\, dt\,. \tag{8}$$

Figure 3 presents an example of a hypothetical output function associated with the execution of an activity A. The solid line represents output O_A as a function of input r_A, in the monotasking condition[22]. Possible modifications in the output deriving from the execution of the same activity under a condition of multitasking may shift the curve respectively upward (if the multitasking configuration is efficient, and therefore $\eta > 1$), or downward (if the multitasking conditions are inefficient, and consequently $\eta < 1$). Generally speaking, all output curves with an efficiency score $\eta > 1$ lie *above* the original curve of monotasking output O_A^{mono}, and the curves with efficiency score $\eta < 1$ would lie *below* it. However, the exact shape of an output curve will depend on many variables (including the factors mentioned in the discussion above), and might appear very different from the examples shown in the Figure 3.[23] The *efficiency* with which multitasked activities are executed will greatly depend on the "compatibility" of the performed activities: an efficient execution of multitasking activities is usually associated with a relatively complete allocation of resources belonging to all domains, and minimum overlaps in contemporaneous "calls for resources" of the same kind that might reduce the performance of the system (i.e. the *human being*, when studying multitasking behavior, or a manufacturing facility, when studying production processes).[24]

The discussion, so far based on the execution of one or two different activities, can be analogously extended to a more general context in which the available resources are allocated among more than two activities. This case could eventuate in a more complete allocation of the total available resources, provided that the various activities are compatible with allocating the resources belonging to the separate domains. However, the execution of too many tasks can also involve problems associated with the overhead (switching and mixing) costs (i.e. costs the individual incurs to allocate resources to multiple tasks and to "control" many processes at the same time) needed to coordinate the different activities: this may result in a

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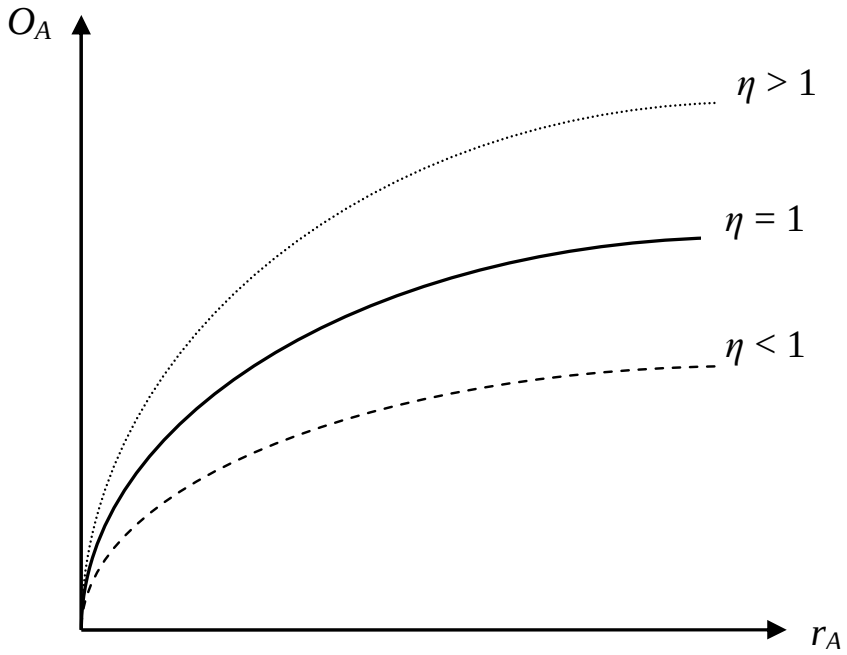
22 The line illustrates the typical case of diminishing marginal returns, in which as more input is consumed, an additional unit of input results in fewer units of output. In some cases, however, the output function may exhibit increasing marginal returns for some range of inputs (representing greater productivity after a "warm-up period"), followed by decreasing marginal returns as the continued input of additional resources loses effectiveness. Various shapes could be possible for this curve, depending on the specific conditions under which the activity is performed.

23 In some specific cases, the execution of two tasks under multitasking conditions might generate efficiency scores respectively greater and smaller than one in different regions of the graph shown in Figure 3. This is the case, for instance, in the multitasking execution of two activities that interfere with each other for very low values of the share of resources R_A, but that have higher efficiency if the share of resources exceeds a minimum threshold (e.g. "minimum level of attention" for an activity to be performed correctly).

24 Following the computer analogy introduced earlier in this paper, the most efficient allocation of the available resources is reached when all different resources in the machine are fully allocated to tasks, with the minimum number of conflicts caused by the simultaneous execution of multiple applications requiring the same resources, which on the contrary would reduce the speed of execution of the tasks and could result in errors while running the processes.

decrease in the efficiency of the process, especially in those cases in which more than one activity heavily depends on the use of the same type of resources (e.g. mental). In this case, the multitasking experience that "expands" the 24-hour day may be replaced by a less satisfactory experience of non-fulfillment of the individual's needs, and by a general effect of fatigue, together with a perception of reduced functionality associated with a decrease in output (as popularized by Hallowell, 2006, among many others; also see Mark *et al.*, 2008).

Figure 3
Examples of the variation in the output from activity A as a function of the multitasking efficiency level



$\eta > 1$: high efficiency (positive interaction between activities)
$\eta = 1$: no interaction between activities (output is as high as if monotasking)
$\eta < 1$: low efficiency (negative interference between activities)
Source: Own illustration.

4 The time dimension – The period of observation and the granularity of time

The resource (vertical) dimension of the two-dimensional typology introduced in Section 2 was extensively explored in Section 3. We turn now to the horizontal dimension, *time*. Several researchers have identified the time dimension as critical in the analysis of multitasking (Bluedorn *et al.*, 1992; Kenyon, 2010; König and Waller, 2010; also see Salvucci *et al.*, 2009). The definition of multitasking in terms of the engagement in two or more tasks *at the same time* is in fact not free from ambiguity. Greater clarity with respect to the specification of these time-related variables is needed in order to properly classify multitasking activities

(and polychronicity orientations). The discussion in this section has direct implications for the design of time use data collection instruments and the analysis of time use data.

Two (related) aspects dealing with time are important in the analysis of multitasking. The first one refers to the *length of the period of observation* during which activities are recorded: we will probably have a different view of multitasking as "doing more than one activity *at the same time*" if we plan to observe a group of participants over one hour, as opposed to during one year. The second aspect refers to the *time granularity*, or *size of the time unit*, over which activities are recorded: once the period of observation has been defined (e.g. one hour), we can obtain very different results if we treat the entire period as a single unit (e.g., simply determining whether one or more activities were performed during that hour), compared to recording a participant's multitasking status at each of many small subdivisions of time (e.g., recording the number of activities an individual was performing during each five–minute interval of the hour). Differences in these two time-related dimensions are partly responsible for the considerable variation in the definition of multitasking in research studies and in the design of activity and travel surveys, as well as in the perception among different individuals of what multitasking is and whether they enjoy it or not.

We use the term "granularity" to refer not only to the length of a unit of time, but also to the level of detail characterizing a task or activity (finer-grained: "talked to a colleague"; coarser-grained: "worked").[25] Many studies of multitasking behavior incorporate a certain level of *granularity in activity* through the categories or examples they offer. If granularity in activity is not specified, however, we believe that the natural tendency is to adjust the two granularities in tandem: as the time scale becomes coarser, the definition of what constitutes an activity does the same. For example, if a person were asked to recount his activities of a certain single hour, we might see a characterization such as "answered the phone, sent and replied to e-mail messages, walked across the hall and talked to a colleague". However, we might obtain a very different answer if we asked him to recount his activities of the one-day period containing that same hour, where the hour in question might be covered by the single activity "worked". That being said, it is unlikely that everyone would make the same adjustments: some people will think and express themselves in greater detail than others, and thus, for some people, the list of activities for a one-day period might in fact be a lengthy list at a finer level of task granularity.

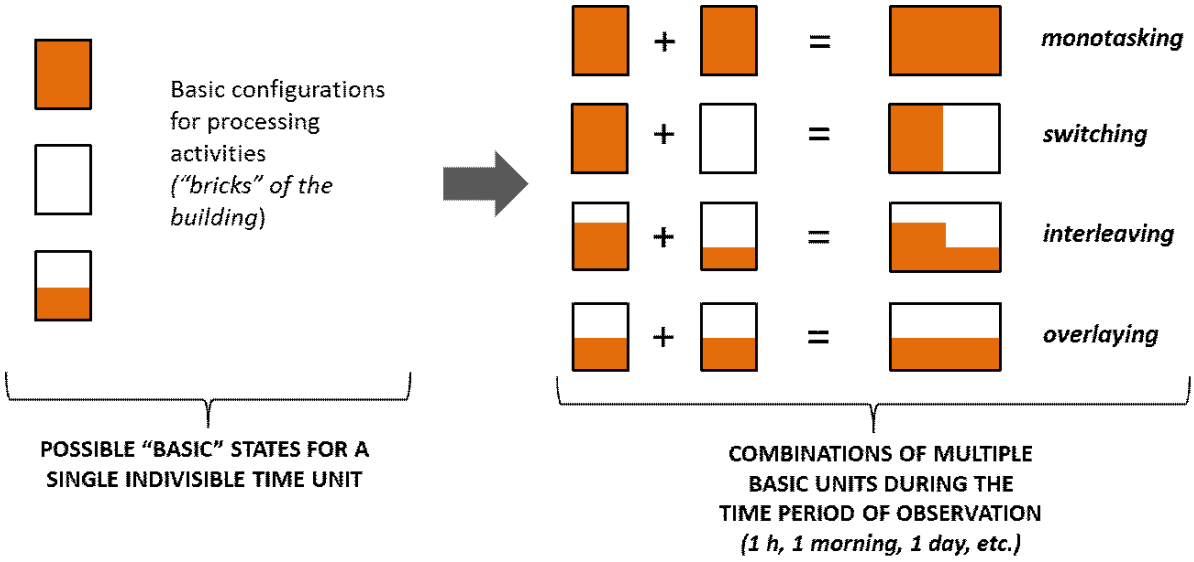
To continue the discussion of the two time-related aspects: let us consider the smallest unit of time that is of interest to a given study to be indivisible for measurement purposes, and let us again restrict ourselves to the simple case of two activities fully occupying all resources at

[25] The three-tiered classification system of the American Time Use Survey (http://www.bls.gov/tus/lexiconnoex2009.pdf, accessed March 25, 2011) is a good example of a hierarchy in activity granularity. The upper tier contains only 17 coarse-grained categories of time use (for example, category 12 is "socializing, relaxing, and leisure"), each of which has a number of finer-grained second- and third-tier categories below it (e.g., 1204 is "arts and entertainment (other than sports)", and 120403 is "attending movies/film").

any given moment. We immediately realize that there are only three types of states by which that indivisible unit of time can be classified: fully devoted to task A, fully devoted to task B, or partially devoted to both A and B. Note that the first and second states constitute monotasking, while the third state is overlaying – for an indivisible unit of time, by definition we cannot identify switching or interleaving, since those imply the ability to measure a $T_1 < 1$ (see Appendix A), which would require the divisibility of the time unit.

The entire period of observation, however, consists of multiple (indivisible) units of time placed side by side horizontally. Viewing the three states identified above as our possible "building blocks" across time, we observe that all four types of mono/multitasking can be realized, as long as the period of observation comprises more than one indivisible unit. As shown in Figure 4, we obtain switching when the first and second states are juxtaposed, and we obtain interleaving when two different cases of the third state are juxtaposed.

Figure 4
Combination of basic configurations of "activity processing" to create more complex monotasking or multitasking patterns



Source: Own illustration.

It is of interest to ask, what types of multitasking can occur down to the finest level of time granularity? Returning to some examples from Section 3, it appears that we can walk and talk at the same time, down to any practically meaningful unit of time.[26] By contrast, the juggling example is a case in which the performer is *alternating* physical actions in rapid succession: physically *switching*, while presumably mentally *interleaving* what she is currently doing with

[26] The phrase "walk and chew gum at the same time" is a colloquial metaphor for overlay at coarser task granularities. As but one topical example drawn from the news at the time, on January 28, 2011, Googling the string <"walk and chew gum at the same time" Obama> returned 200,000 hits, both supporting and disputing the U.S. presidential administration's claim to be able to effectively address multiple policy initiatives simultaneously.

what she will be doing in the next moments. Thus, for fine-grained units of time, we suggest that a complete *overlay* of one task on another is far more likely to be feasible when the two tasks represent different combinations of values on the five pertinent domains (for example, the "virtually perfect time sharing in dual-task performance" found by Schumacher *et al*., 2001, involved simultaneously speaking and pressing a key in response to two separate stimuli). Following Hallowell (2006), a complete overlay appears possible when one task primarily involves the cerebellum and the other involves the frontal lobes. On the other hand, when the two tasks actively conflict in the allocation of resources belonging to the same domain, multitasking is more likely to be represented by the *switching* or *interleaving* forms. In Section 5.2, we revisit this question in the context of the designation of tasks as active versus passive.

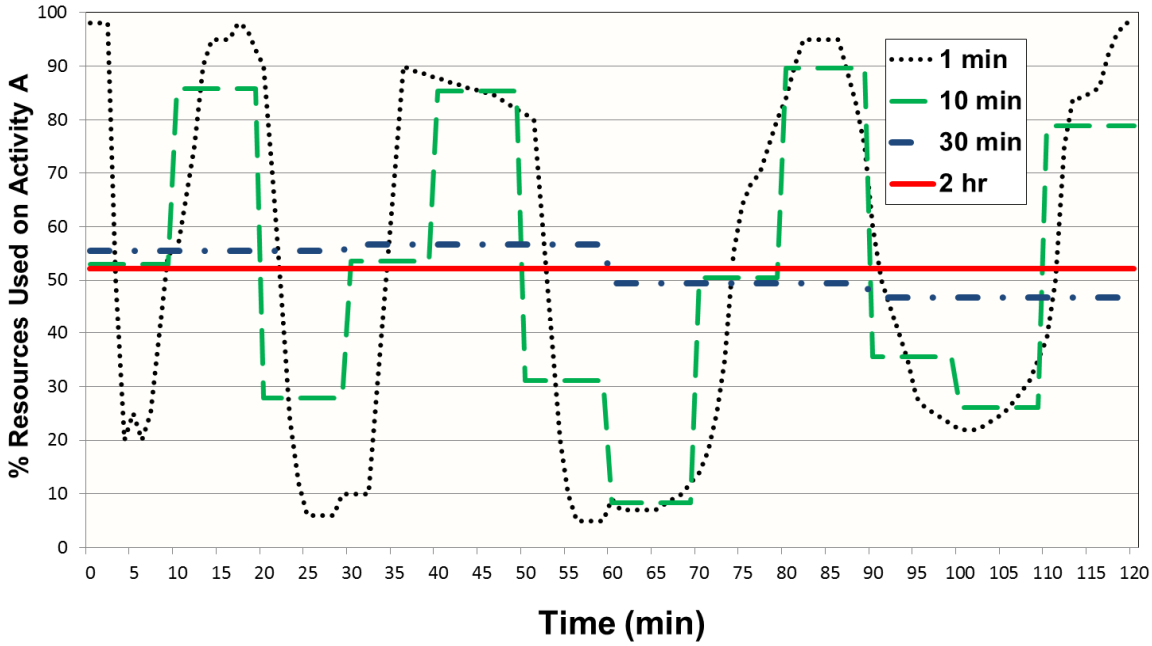
For illustrative purposes, the horizontal dimension of the graphs in Figure 1 used a generic unit of time to measure multitasking activities. However, the conceptualization of multitasking and polychronicity may vary depending on the time scale in which activities and preferences are measured. This effect is expected to become rather significant when moving from small time scales (e.g. seconds to minutes) to larger ones (e.g. hours, days or even weeks). In fact, the same activities that are classified as one type of multitasking behavior at one time scale may eventually fit into a different type if measured on a different time scale. For example, two activities which on a coarser scale for time (e.g. hours) may be considered overlaid (simultaneous), e.g. working on a paper and replying to email during a 3-4-hour block of time, would be probably considered interleaved if the time scale is exploded to the level of minutes (or seconds). Figure 5 shows how different time units can lead to a different perception of the allocation of the available resources, and eventually to different classifications of the simultaneity of multiple tasks.

It is important also to note that many single activities that individuals carry out during any day could be recorded as "multitasking", depending on the way activities are measured. For example, even writing a paper (considered a single "task") may require performing multiple coordinated activities "simultaneously": one may be concurrently typing words on a keyboard, reading on a screen what is being typed, and thinking about what has just been, and what is about to be, typed (Baron, 2008). Although such situations, involving an interconnected *bundle* of activities integral to the conduct of a single task, are not generally thought of as "multitasking", the example illustrates how the definition of multitasking may vary among individuals, and according to the specifications and information used for data collection in a research project (we return to this point in Section 6).

Finally, the discussion reported in Appendix A describes the *continuous* paths that link the possible different classifications of activities in a monotasking/multitasking environment. However, we reiterate that the empirical categorization of activities into one of those types often depends on the time scale used to measure the involvement in the various activities. Further, different perceptions of multitasking may be associated with similar behaviors depending on the methodology used for the data collection, the instructions given to the re-

spondents, and the way the information is treated in the analysis of the available data (Kenyon, 2010). The cultural background and the sensibility with which actors perceive the allocation of their time and attention also affect the perception of multitasking activities.

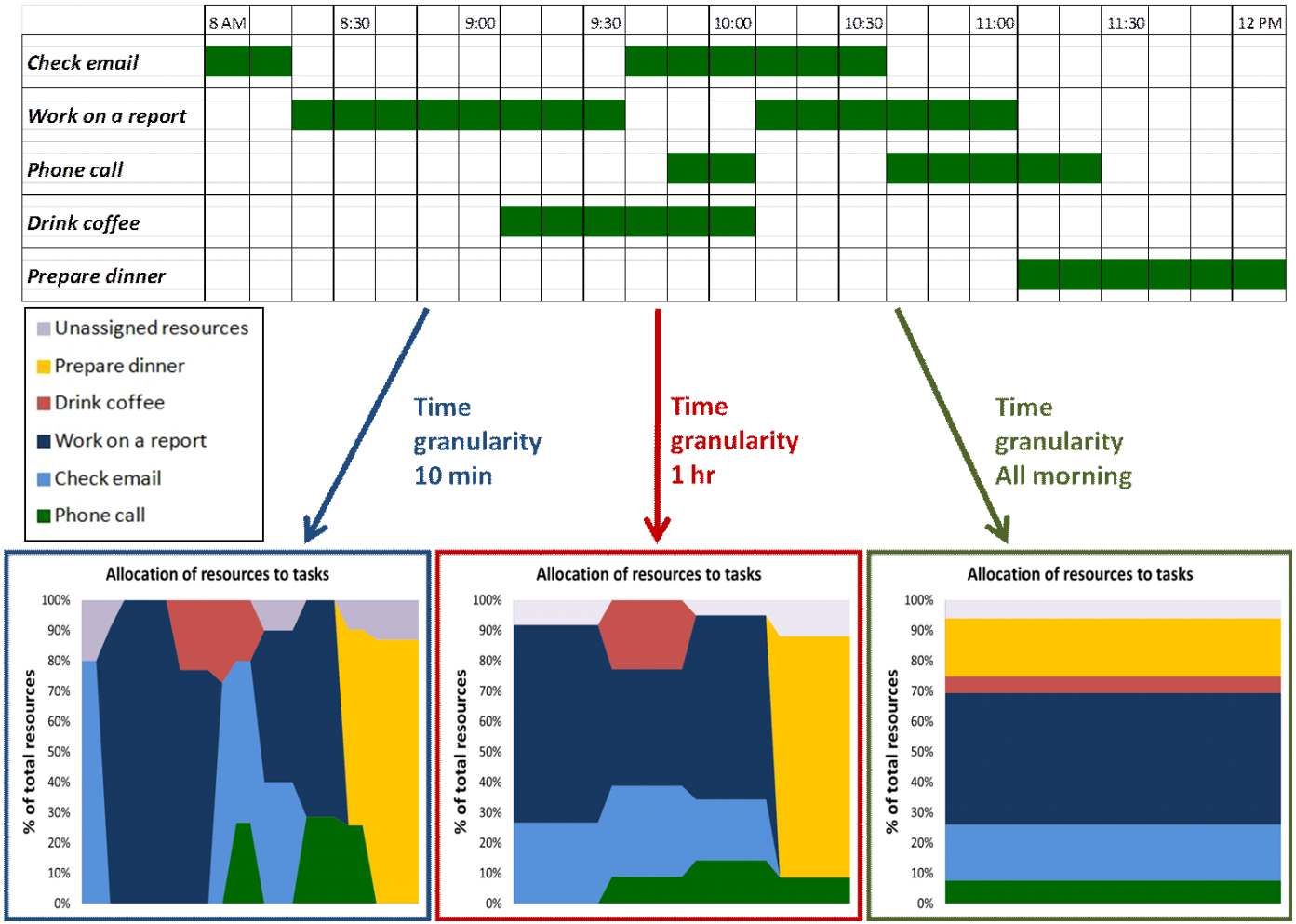
Figure 5
The execution of multiple activities can be classified very differently (from "switching" to "interleaving" or even "overlaying") when the time granularity gets coarser



Source: Own illustration.

Imagine, for example, that multitasking behavior is measured via a time use diary like the one shown in the upper portion of Figure 6. The lower portion of the figure makes it clear that the granularity used to analyze the data can lead to very different apparent behavioral patterns. At the coarsest time granularity, it is impossible to know whether in "real time" the six recorded activities took place in a sequential, interleaved, or overlaid fashion, and yet those three possibilities would represent quite different polychronic orientations for many study purposes.

Figure 6
The impact of time granularity on time use pattern classification



Source: Own illustration.

5 Fundamental relationships between two multi-tasked activities

The previous sections of this paper have discussed the two dimensions of "share of resources" and "share of time" to analyze and classify multitasking behavior. In this section, we will now focus on the *nature* of the activities to be performed, and how that influences the classification of multitasking and the corresponding polychronic attitude. Probably most scholars studying the phenomena of multitasking and polychronicity have grappled with the question of "where to draw the line".[27] Such a boundary is often difficult to define, and its definition is further complicated in view of the "morphability" of each form of multitasking into each other form and the ambiguity about what constitutes "simultaneity" at different levels of time and activity granularity (Appendix A and Section 4). One likely reason for the attempts to "draw the line", however, is the valid realization that a simple definition of "doing more than one thing at a time" is ambiguous and can include markedly different kinds of scenarios.

In this paper, we lean toward a perspective that is more rather than less inclusive: we believe it is useful to map out the large terrain or landscape potentially covered by these concepts, so as to have a better sense of the broader context when one decides to study a particular smaller region of that terrain. In the next section we present a (systematic but by no means exhaustive) *library* of multitasking examples, which is helpful to illustrate the diversity of regions of the terrain. The present section sets the stage for that discussion by addressing some key dimensions along which multitasking activities can differ and by which the entries in our library are classified.

5.1 Primary versus secondary

Among the first questions that arise from the definition of multitasking, in which we refer to conducting two or more activities at the same time, is "which one is more important"? This designation is likely to drive other decisions about the set of activities being performed, and thus to provide important contextual information to the analyst seeking to understand the choices made. For example, if grading papers is the most important activity for an instructor, the volume on the television may be turned down (or off) and the activity may be solitary, whereas if watching the soccer game is the most important activity, grading papers may be limited to the multiple-choice sections rather than the essay sections, and a number of friends may be present.[28] Thus, which activity is the main one is a critical piece of information to elic-

[27] For example, as mentioned in the Introduction, Arndt *et al.* (2006) exclude "task-switching" from the concept of "multi-tasking", restricting the latter to mean "simultaneous-tasking".

[28] Another example: if asked, "do you like to mix business and pleasure?", one of us would reply, "I like to mix pleasure with business (so I try to do some sightseeing while on an overseas business trip), but not the

it from a respondent. This is particularly true if the survey instrument only allows for a single activity to be recorded in any given time slot (as is the case for some time-use surveys). However, the importance ranking of the performed activities is also valuable when *multiple* activities can be reported.

Kenyon (2010) reviews the definitions of "main" or "primary" activity in five different time use surveys. Interestingly, the definitions vary significantly: (1) the respondent-identified "main" activity or, failing that, the first one mentioned by the respondent in the interview; (2) the respondent-identified "main" activity or, failing that, the one conducted "for the longest time"; (3) the respondent-identified "main" activity, with guidance by example; (4) the "most important" activity; and (5) the two activities that "demanded most attention" (used to select two activities when more than two were conducted simultaneously). She notes that any of the three activities "watching television", "watching children", and "drinking tea" could be considered "main", depending on which definition is applied.

Three of the five surveys essentially allow the respondent to decide which one is the main activity. Although it is likely that many people have a good instinct regarding which activity is the main one for them, it does impose an extra burden to have to make that decision with little guidance. Many people are not particularly introspective or self-analytical, and even those who are may find the decision difficult to make in the absence of more specific instruction. The "demands most attention" criterion may be useful as a means of selecting among three or more simultaneous activities, but (1) if used to select which single activity to report, it may omit some activities that are of particular interest in some contexts (e.g. the use of the television or MP3 player as "aural wallpaper", always-on in the background), and (2) it may yield problematic results when the share of resources varies substantially between tasks over time (as shown by Figure 1). The "most important" criterion is better than nothing, but begs the question of how "important" is to be defined, and is therefore somewhat tautological with "main" or "primary".

We do not claim to have the definitive answer to this dilemma, and indeed (1) there may not be only one right answer, and (2) it is certainly possible that two activities could be "tied" with respect to any particular criterion. However, a criterion that we have found useful is to think of the primary activity as "the one you would be doing anyway", whereas secondary activities are "incidental" to the main one[29]. Are you watching TV (secondary) while prepar-

converse (so I seldom check e-mail while on vacation)." The classification of business or pleasure as primary or secondary substantially affects the likelihood of choosing a pleasure/business combination of activities, and the preference for undertaking such a combination.

[29] A relevant example in which different respondents may have different perceptions of what is "multitasking" is that of reporting secondary activities conducted during traveling, e.g. while commuting to or from work. While listening to the radio may be a usual activity for many commuters who travel by car to work, many respondents may not consider it to be properly "multitasking", since it is an activity conducted only as a consequence of the need to commute to work, not something that they would otherwise take the time to do independently of the trip. Therefore, they might be induced to consider the commute a "single activity" (*driving to work*), focusing their attention on the primary activity they would have done anyway, and wit-

ing dinner (primary), or conversely preparing dinner while watching TV? For many people it is the former, but if the TV show is your favorite reality show, it may be the latter.[30] Note that, according to this criterion, the primary activity may not always be the one demanding the most resources at that point in time: for example, the primary activity could be "riding the bus to work", while the secondary activity is "reading", even if the latter claims most of one's resources during the trip.

5.2 Active versus passive

It may sometimes be natural to confuse the *active* vs. *passive* dimension with the *primary* vs. *secondary* dimension, but we believe they are conceptually distinct (and the last example of Section 5.1 illustrates the difference). We define "active" to mean "involving the deliberate use of one's *physical and/or mental faculties*", and "passive" to be the opposite. Another way to view it is that passive activities are things "happening" without current input from the individual (even if she set in motion the activity at an earlier point in time), whereas active tasks require the individual to be *doing* something, whether mental or physical.[31]

Let us, however, stipulate two things. First, *active* vs. *passive* is a continuum, not a dichotomy; there are, more realistically, various degrees of activity/passivity, which depend on the share of resources that the individual invests in the activity and on the specific nature of such activities. Second, the degree of activity/passivity is not a static property of a task or combination of tasks. Rather, a given task can fluctuate in its degree of passivity over time. Thus, for example, when doing a load of laundry while working, sometimes the laundry requires *active*

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hout focusing on the option for multitasking enabled by listening to music or to the news broadcasted by the radio. The availability of a new technology, e.g. an MP3 player or more sophisticated satellite radio, might "reverse" this perception, prompting the travelers to focus more on the advantages offered by one travel solution, e.g."driving alone" in terms of access to music and media (or "transit" in terms of the improved possibilities for watching movies, playing online games, or carrying out work activities while traveling).

30 As an example of the difficulty presented by this definition, consider the teenager who always has his MP3 player on in the background. He may consider that he'd be listening to music no matter what else he'd be doing, whereas in reality, "homework" is what he would be doing anyway, while the music is incidental (Wallis, 2010 has an interesting discussion of this point on p. 5).

31 This contrast loosely corresponds to Wickens' dichotomy between perception/cognition and responding. Admittedly, however, as we have conceived it, a passive activity may, in fact, be so far in the background that it is not even perceived, i.e. not calling on *any* human resources for a while. For example, one may "completely forget" that he has put a casserole in the oven, and yet the casserole is still cooking in the meantime. Eventually the task of cooking the casserole begins to call on human resources again: first at the passive level (when an odor or a timer signal is perceived or even just when the cook, without an external stimulus, recalls that it is in the oven), and then at the active level (when he resolves to check on it and then actually does so). This and similar examples suggest that the resource vector discussed in Section 3 could, in some contexts of interest, include a dimension of resources *external* to the individual (e.g. the oven heat – or, for that matter, the transportation vehicle). When such a dimension is accounted for, then the activity of cooking dinner is considered to be *overlaid* with the secondary activity being conducted while the casserole is heating, with episodes of *switching* or *interleaving* when the casserole is put into and taken out of the oven. Without such a dimension, cooking would only be switched or interleaved with the other activity, not overlaid. The latter treatment, however, does not convey the necessity of the *elapsed time* in cooking dinner, and we believe that in many applications, it is important to make explicit the requirement for a certain amount of time to elapse in the conduct of a given activity.

attention, while at other times it is operating *passively* in the background. As mentioned, however, this is not the same thing as *primary* vs. *secondary*, and various combinations are possible. For instance, in the last example of Section 5.1, the primary activity of riding the bus is largely passive, whereas the secondary activity of reading requires significant mental resources, and is active.

In general (again speaking in terms of stereotypes, recognizing that reality is more blurry), we suggest the following principles: (1) Both the primary and the secondary activities could be *passive* under any of the types of Figure 1. (2) When two or more tasks are *active*, they can be successfully *overlaid* only if each task uses resources in different domains (see Section 3). Attempting to overlay two active tasks requiring the *same* type of resources is apt to lead to a collision of some kind.[32] (3) Conversely, two or more *active* tasks requiring the same type of resources can be successfully multitasked (if at all) only in the context of *switching* or *interleaving.* (4) Two or more tasks requiring the same type of resources can be most successfully *overlaid* if one of them is *active* and the others are *passive* (although, depending on how resource domains are defined, active tasks may, by definition, require different types of resources than passive tasks).

5.3 Are "travel" and "waiting" activities?

Two kinds of time uses deserve special attention, because of their distinctive roles as (often) transitional or interstitial between "the real" activities: travel, constituting a spatio-temporal transition, and waiting, a temporal one. We believe it is useful to treat them as real activities, for two reasons. First, certainly travel, and to a lesser extent waiting, can sometimes be an end (activity) in itself, not just a means to some other end. With respect to travel, a sizable and growing literature is supportive of this point (e.g. Mokhtarian and Salomon, 2001; Diana, 2008; Paez and Whalen, 2010). The point is presumably true far less often for waiting, but it is possible to imagine cases in which an individual actively embraces the discipline of waiting, or the rest it affords, and thus chooses to do so for its own sake (Gasparini, 1995).

Secondly, both travel and waiting practically invite other activities to be overlaid on them: precisely because they are often viewed as otherwise unproductive transition times to a target activity, there can be a strong motivation to redeem the time by using it productively. Accordingly, it seems reasonable that a comprehensive view of multitasking should take an interest in the activities conducted while traveling and while waiting. Certainly, choices made with respect to those overlaid (or interleaved) activities can affect choices about the traveling, wait-

[32] A good example is the current campaign in the United States and elsewhere to prevent sending text messages while driving; see, e.g., http://www.distraction.gov/, accessed July 30, 2010, or Google the phrase "distracted driving". In the context of Wickens' (2008) multiple resource hypercube, these two activities are both response-oriented (not just involving perception/cognition), spatial, visual, and focal (as well as partly physical and partly mental, potentially requiring the same parts of the body in both cases). Thus, it is no surprise that it is difficult to competently conduct both at the same time. It is impossible to truly overlay them for more than a few seconds, and therefore conducting them both together involves rapid switching/interleaving between them.

ing, and/or the target activities to be performed. For instance, the ability to multitask may increase the utility associated with those travel solutions that facilitate the execution of working (or leisure) activities while traveling (Ettema and Verschuren, 2007), as is often the case for transit services. And equally certainly, for this reason providers of goods as well as transit operators are eager to find ways to help travelers and waiters use their time in a desired way – both as a retail market in its own right, and to increase customer satisfaction with the transportation service or the activity engendering the waiting. This, of course, is the logic behind providing magazines near checkout stands in stores (e.g. Bennett, 1998), and numerous other diversionary practices, such as providing free magazines and/or newspapers on board airplanes, trains and buses – to say nothing of the widening variety of digital entertainment options being provided on vehicles.

For these reasons, we consider activities conducted while traveling or waiting to be forms of multitasking. There is, in fact, a burgeoning literature on activities conducted while traveling (e.g. Jain and Lyons, 2008; Watts and Urry, 2008; Zhang and Timmermans, 2010) which largely takes the same perspective, whereas waiting seems to be less often studied (but see, e.g., Bissell, 2007; Durrande-Moreau and Usunier, 1999; Friman, 2010; Gasparini, 1995; Watkins et al., 2011).

What can we say about these two types of activities with respect to the classifications discussed in Sections 5.1 and 5.2? Regarding the primary versus secondary distinction, whenever traveling or waiting is, in fact, the means of transitioning to a target activity, it is generally the primary activity in its time interval (i.e. the activity "which would have been done anyway"). Any overlaid or interleaved activities will be secondary. However, when it is conducted for its own sake (again, more common with travel than with waiting), it can be either primary or secondary. The library of examples discussed in Section 6 includes all of those types of situations in the case of travel; the case of waiting is treated only as transitional, and therefore only primary.

With respect to waiting, the issue of granularity (Section 4) becomes relevant to the question of "where to draw the boundaries". At a very coarse time (and activity) scale, long periods of an individual's life might be spent "waiting"[33] : waiting for one's birthday as a child, or an anticipated vacation as an adult; waiting to finish school, to find a life partner, for the baby to be born, for the dream job to come along, for a loved one to return from a dangerous assignment, and so on. Although these are legitimate forms of waiting, it is certainly true that other (finer-grained) primary activities will be overlaid onto those, and given our context of investigating the activity patterns of daily life, we will exclude those forms of waiting from our scope of interest.

As the granularity gets somewhat finer, however, the longer-term form of waiting also blurs into a type that some scholars (e.g. Kaufman-Scarborough and Lindquist, 1999b, Kenyon,

[33] One could make a similar comment about "traveling", in fact that one's entire life is spent traveling, in the metaphorical but relevant sense that "life is a journey".

2010) consider in the context of multitasking: the concept of being "on call". Time frames for being on call might typically range from hours to days (though they could sometimes be shorter or longer). During that time, one is able to overlay or interleave other primary (eating, sleeping, other work, and so on) and secondary activities, but the background on-call status does impose constraints on those other activities (such as limiting one's geographic mobility) and recurrently claims a share of resources. The doctor who eats while on call, or the mother who works while her children are sleeping, can be considered to engage in a type of multitasking. However, these are qualitatively different from the shorter-term form of waiting, and so they are not hereafter included in the present discussion.

Regarding the active versus passive distinction, waiting in particular will usually be passive. If other activities are conducted while waiting, then those activities can be active, but the waiting itself is passive. Travel, on the other hand, can be either active (driving, boarding the plane, bicycling) or passive (sitting in a vehicle driven by others), depending on the share of resources that the particular activity requires.

For the purposes of developing the systematic set of examples discussed in Section 6, we treat waiting as a special case of a passive activity that is of separate interest, but classify each example of waiting as falling under the activity for which the waiting is occurring. For example, waiting for a movie to start would be classified under "leisure" (the movie), waiting in the doctor's office would be classified under "personal care" activities, and waiting for a bus would be classified under "travel". Waiting can occur during as well as before an activity, such as waiting to change trains (during travel), waiting for the dryer to finish or the dinner to cook (during maintenance), at the intermission of a concert (during leisure), and so on [34].

6 A library of multitasking examples

As mentioned in Section 5, we have developed a systematic compilation of multitasking examples so as to illustrate the diversity of types of multitasking. The library is useful to inform our own (and, we hope, others') future thinking on the subject, and to help exemplify some of the different natures of multitasking. Table 1 presents that compilation, where the narrative description of each example consists of a secondary activity/primary activity ("doing this while doing that") pair.

[34] Sometimes it is natural to think of waiting for an activity to finish rather than for one to start, but to avoid ambiguity, we consider that to be a case of waiting for the next activity to start. For example, if one is waiting outside the school for one's child to finish class, we consider it to be actually waiting for the trip home with the child to start.

Table 1
A library of multitasking examples

Primary		Secondary	Example
Work	A	Work	Answering the phone while operating a cash register
	P		Checking a work-related email while sitting in a business meeting
	W		Organizing files while waiting for a computer program to run
	A	Travel	Entertaining business clients while on a cruise ship
	P		Relationship building while accompanying a business associate on an excursion
	W		Walking around the block while waiting for a long computer program to run
	A	Leisure	Listening to music while meeting with patients
	P		Texting friends while sitting in a business meeting
	W		Checking your personal email while waiting for a client to arrive
	A	Shopping	Shopping online while writing an article
	P		Downloading a song from iTunes while sitting in a business meeting
	W		Shopping online while waiting for a client to arrive
	A	Personal/ domestic care	Watching the children during the day while working from home
	P		Filing one's nails while listening to a business conference call
	W		Making lunch while waiting for a long computer program to run
Travel	A	Work	Listening to a work-related audio recording while driving to work
	P		Grading papers while on an airplane flight
	W		Preparing a presentation on a laptop while waiting at an airport terminal
	A	Travel	Walking the dog on a rest break while driving cross-country
	P		Walking around the promenade deck while taking a cruise
	W		Exploring the city near the terminal while waiting for a train
	A	Leisure	Listening to the radio while driving to work
	P		Watching a DVD while taking a train to work
	W		Listening to an MP3 player while waiting for the bus
	A	Shopping	Browsing the store windows while riding a bike downtown
	P		Browsing the Sky Mall magazine while flying to a different country
	W		Shopping at the airport while waiting for a connecting flight
	A	Personal/ domestic care	Putting on makeup while driving to work
	P		Eating while riding the bus
	W		Eating breakfast while waiting for the train
Leisure	A	Work	Reading a work-related email while surfing the internet
	P		Talking to clients on a mobile phone while sitting on the beach
	W		Reading work-related email messages during the intermission of a play
	A	Travel	Going for a hike while on a camping trip
	P		Driving around while listening to a new CD
	W		Bicycling to the convenience store during the halftime break of a televised football game
	A	Leisure	Listening to music while playing a card game
	P		Reading a novel while sitting on the beach
	W		Unexpectedly seeing a friend and chatting with her during the intermission of a play
	A	Shopping	Window shopping while hanging out with friends downtown
	P		Shopping on the internet while listening to a TV show podcast
	W		Shopping at the stadium pro shop during halftime at a football game
	A	Personal/ domestic care	Doing laundry while reading a book
	P		Cleaning house while watching a soap opera
	W		Loading the dishwasher during a commercial break on TV

Table 1 Cont.
A library of multitasking examples

Primary		Secondary	Example
Shopping	A	Work	Reading work-related email in the middle of making an online purchase
	P		Reading work email at the theater while advertisements are playing before the movie starts
	W		Reading a work-related email while waiting for a dressing room at the department store
	A	Travel	Taking a cruise for the purpose of shopping duty free
	P		Walking from the hotel to dinner while window-shopping on a shopping vacation
	W		Walking to the coffee house while waiting for an online auction to end
	A	Leisure	Encountering a friend and chatting with him, while shopping
	P		Playing a game at the theater while advertisements are playing before the movie starts
	W		Reading a magazine while waiting in line at the cash register of a store
	A	Shopping	Browsing the internet for the lowest price while shopping in a store for a specific DVD player
	P		Downloading an MP3 file at the theater while advertisements are playing before the movie starts
	W		Continuing to browse eBay while waiting for a specific bid time to end
	A	Personal/ domestic care	Eating lunch while walking through a mall to find a gift to purchase
	P		Eating a snack at the theater while advertisements are playing before the movie starts
	W		Sleeping while waiting in line for a new game system to be released
Personal/ domestic care	A	Work	Taking a business phone call while grocery-shopping
	P		Doing paperwork for work while supervising the children
	W		Taking a business call while waiting for dinner to finish cooking
	A	Travel	Walking around a park on a break from riding a bicycle for exercise
	P		Going for a walk with a sleeping infant in the stroller
	W		Going for a walk while waiting for dinner to cook
	A	Leisure	Listening to music while housecleaning
	P		Reading a novel while supervising the children
	W		Reading a novel while waiting for the dishwasher to finish running
	A	Shopping	Clipping coupons while eating breakfast
	P		Shopping online while watching the children
	W		Leafing through a catalog while waiting for the laundry to dry
	A	Personal/ domestic care	Packing a lunch for the children while making breakfast
	P		Cleaning the house while watching the children
	W		Cleaning the kitchen while waiting for dinner to cook

Note: A=active; P=passive; W=waiting
Source: Own definitions.

Five different activity types/purposes are treated: we augment the conventional (e.g. Reichman, 1976) triad of mandatory (work), personal/domestic care [35], and leisure activities with the additional specific groups of activities for shopping (commonly classified as a personal/

[35] In travel behavior analysis, trip or activity purposes are conventionally classified as mandatory, maintenance, or leisure. To be more congruent with the terminology employed in time use studies, we here use "personal/domestic care" in lieu of "maintenance". The intended meaning in both cases is essentially that contained in major divisions 6 (unpaid within-own-household domestic services), 7 (unpaid caregiving services to own-household members), and 15 (personal care and maintenance) of the International Classification of Activities for Time-Use Statistics (ICATUS; see http://unstats.un.org/unsd/class/intercop/expertgroup/2009/AC190-Bk4.PDF, accessed October 5, 2012).

domestic care activity, but receiving special attention of late in the context of online shopping) and travel. Each purpose for the primary activity is paired, one-by-one, with each purpose for the secondary activity. For each of those 25 pairs, we offer three examples, in which the primary activity is respectively active, passive (other than waiting), or waiting. Thus, our library consists of 75 examples of primary/secondary pairs. In the discussion below, we will refer to specific examples, using designations such as "work (A) leisure" to mean "work as an active primary activity paired with leisure as secondary" and "personal/domestic care (P) shopping" to mean "personal/domestic care as a passive primary activity paired with shopping as secondary".

The activities used as examples involve diverse units of time analysis (from minutes to several hours or days). As discussed in Section 4, the time granularity and the period of observation are important time-related aspects of classifying multitasking activities. The purpose of this library, however, is to call attention to the wide range of combinations of primary vs. secondary and active vs. passive activities. In so doing, we include examples measured on different time scales so as to reflect the variety of interpretations of multitasking that is present in the literature.

To begin the discussion of the table, we remind the reader that "while", or "at the same time as", can refer to interleaving or switching as well as overlaying. As mentioned in Section 5.2, the former meanings are especially likely to apply when both activities are "active". Thus, for example, in the "travel (A) travel" entry of the table, one is not literally walking the dog while simultaneously driving across the country, nor, in the "work (A) shopping" entry, is one shopping online and writing the article in the same instant.[36]

Although for the most part the examples are quite plausible – even common – constructing the library highlighted two combinations for which the scenarios seemed relatively contrived:

1. *Examples in which shopping is a passive primary activity*. After extensive thought, we decided that being exposed to advertising could be considered *passive shopping*. It is a stretch to call it "primary", but in our examples involving doing other things while advertisements are playing before a theater movie begins, it fulfills the criterion we proposed in Section 5.1, as being "what you would be doing anyway" (in the sense that the advertisements are the necessary concomitant to the subsequent movie). However, these examples could be also considered cases in which the primary activity is "waiting" and shopping is

[36] These examples also, once again, illustrate the role of time granularity. For the most part (by design), the examples fall into a typical time scale of minutes-to-hours. But even so, variation is possible in the classification of an activity into multitasking archetype. At the scale of hours, or even a relatively small number of minutes, one can do both activities "at the same time" (thus, overlay one on the other). At the one-minute scale, however, switching (in the first example) or interleaving (in the second) is a far more natural classification.
We also remind the reader that the designation of primary versus secondary may sometimes depend on the perspective of the actor – except in the case of waiting, which we always take to be primary, and, in many but not all cases, travel. Thus, we classified "reading a work-related email while surfing the internet" as "leisure (A) work", but for a given individual the priority could easily be reversed.

therefore considered as the secondary passive activity done while waiting. This shows how difficult it is sometimes to classify multitasking behavior even for researchers, and confirms the fuzzy and subjective boundaries that distinguish the various categories for each of the dimensions that have been introduced in this study so far.

2. *Examples in which travel is the secondary activity, especially when the primary activity is classified as "active"*. This is because travel requires movement through time and space, whereas the primary activity limits the extent to which that movement is plausible. It is also a consequence of our decision to exclude examples in which a single activity serves two purposes at once, for it is easy to think of examples in which a single activity is fulfilling a different primary purpose *through* traveling (work: driving a truck for a living; personal/ domestic care: physical exercise through bicycling; leisure: recreational sailing).

The examples reported in Table 1 offer an overview of many possible categories of multitasking as combinations of primary vs. secondary and active vs. passive (or "waiting") activities. As mentioned earlier, however, the empirical reality is often more vague, and many intermediate cases (or cases in which personal interpretations could result in recoding multitasking configurations in different ways) exist. Appendix B further expands this discussion, and starting from the case in which a single activity serves two purposes it develops a continuum of the degree to which multiple tasks are distinct/distinguishable.

Overall, the spectrum of examples and "boundary cases" that have been presented illustrates and reinforces the need for greater specificity in what is meant by multitasking, as well as polychronicity, in any particular study. Would we expect a single individual to be equally inclined toward each combination of activities shown in Table 1? If not, and if a survey simply asks the respondent whether he likes doing two things at once, who knows where he is placing himself in this heterogeneous landscape when he replies? Our goal is for this compilation of examples to help future researchers (including ourselves) more effectively identify what regions of the terrain *they* want to survey – both to themselves and to their study participants – and to suggest ways of more systematically sampling from a "universe" of multitasking scenarios in those regions. In the following section, we explore in greater detail this notion of heterogeneity across the spectrum of possibilities in multitasking behavior and polychronic preferences.

7 What does it mean to be polychronic?

There is a sizable and valuable literature dealing with the relationship of an individual's polychronicity to other variables of interest[37]. For the purpose of the present discussion, however,

[37] For example, several authors have associated the concept of polychronicity with the emergence of specific traits affecting social and working habits. Individuals with more polychronic attitudes are often considered better able to deal with frequent interruptions and more suited to working in retail and in other work

we focus on the literature relating to the measurement of polychronicity itself. Several scales to measure polychronicity have been proposed, and applied in numerous empirical studies. Among these, the most commonly used are the Polychronic Attitude Index (PAI) (Kaufman *et al*., 1991), its modified version PAI3 (sometimes called MPAI3) (Kaufman-Scarborough and Lindquist, 1999b) and the Inventory of Polychronic Values (IPV, Bluedorn *et al*., 1992; Bluedorn *et al*., 1999). The PAI is created from the responses to four statements regarding preferences toward the use of time. One of the statements, which referred to specific behavioral preferences and adopted situation-specific language, was later removed from the index, generating the Modified PAI3 (Kaufman-Scarborough and Lindquist, 1999b). The IPV was the result of refined statistical analysis of data on preferences and behavior, and is based in its final version on the responses to 10 statements. All these indices have been applied by the same and other researchers in many different contexts for the evaluation of polychronic preferences (Plocher *et al*., 2002). Lindquist and Kaufman-Scarborough (2007) have also presented an improved scale for the measurement of polychronicity attitudes, the Polychronic-Monochronic Tendency Scale (PMTS), which is based on the responses to five statements.

We have two reflections regarding these existing scales. First, all of them synthesize the responses to multiple statements that collectively measure multiple constructs: behavioral traits, norms, and personal preferences toward polychronicity. However, in other well-known psychological theories (such as the Theory of Reasoned Action; Ajzen and Fishbein, 1980), such constructs are considered to be conceptually distinct, and as having hypothesized causal relationships among them. Combining them into a single scale precludes the possibility of understanding such (potential) causal relationships among them – i.e. separating personal preferences towards polychronicity from normative beliefs on polychronicity and from actual multitasking behavior (Slocombe, 1999). This is a major motivation behind the promising recent development of the 14-item Multitasking Preference Inventory (MPI), which is focused exclusively on *personal affinities* for various descriptions of mono- or multitasking contexts (Poposki and Oswald, 2010).

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structures that require fast execution of tasks and prompt response to customers' requests (Arndt *et al*., 2006). They may perform better in more culturally (and otherwise) varied environments, and have a stronger capacity for adjustment that drives them toward an increased "learning goal orientation" (Schell and Conte, 2008). Conversely, monochronic people usually prefer to "center their attention on one thing and then move on to something else" (Hall, 1959, p. 178), and therefore achieve better performance in the execution of the primary task in strong *non-multitasking* contexts (Madjar and Oldham, 2006; Goonetilleke and Luximon, 2010). The literature also attributes a different perception of time among the two groups of individuals. Polychronic people are said to have a more relaxed perception of time, are less worried by deadlines (Hall, 1983, as quoted in Arndt *et al*., 2006), and have more time (and interest) for socializing and other activities. Further, they better react to changes and other unplanned conditions (Kaufman-Scarborough and Lindquist, 1999a). Finally, individuals' polychronicity attitudes may or may not match the degree of multitasking that is expected in the organization to which they belong (Bluedorn *et al*., 1992), with, as a consequence, rather variable performance outcomes.

However, the MPI shares with its predecessors the basis for our second reflection, which is that in application the commonly-used scales are often completely silent (or at least partly ambiguous) with respect to (a) granularity of time and activity, and (b) activity purpose(s) (work, leisure, etc.). Such information may often be inferred from the broader context in which the scale is being administered. But to the extent it is not made explicit to a respondent, diverging interpretations could result. This issue was offered as one possible explanation for the surprising finding that polychronicity (measured by the IPV) had no significant impact on multitasking performance in at least two studies (König *et al.*, 2005; Ishizaka *et al.*, 2001).

Indeed, in consideration of the diversity of multitasking scenarios exhibited in Table 1, it is the authors' opinion that there will be considerable diversity also in individuals' attitudes and behavior with respect to such scenarios. In our view, in other words, it is conceivable that the same individual may well enjoy (or prefer) one type of multitasking, but not another, thus exhibiting strong polychronic *and* strong monochronic characteristics in different contexts. For example, an individual may be polychronic at a coarse task/time granularity (enjoy working on several *projects* in a week's or month's time), but monochronic at a finer scale (prefer to concentrate on one *task* for several hours at a time) – a condition we could label "macro-polychronic but micro-monochronic", after Ophir (quoted in Wallis, 2010, p. 10). Or, he may be monochronic with respect to work, but polychronic with respect to leisure, or conversely. Some people may relish the challenge of trying to engage similar resources in multiple tasks simultaneously (juggling while riding a unicycle); others may not like that but do not mind engaging *different* resources simultaneously (listening to music when driving); while still others may be "pure" monotaskers.

This helps clarify that a key reason why individuals may have different preferences for different types of multitasking is that they have different *motivations* for multitasking or not, or see different *benefits* or *disbenefits* accruing to it, depending on the type (Cotte and Ratneshwar, 1999). Consider the examples shown in Table 2, in which we illustrate how various combinations of primary vs. secondary and active vs. passive tasks, sometimes together with whether the required resources are complementary or competing, may be undertaken for markedly different benefits or motivations. The person who is multitasking for *relaxation* may have very divergent preferences for a given activity combination compared to the one who is doing it for *stimulation*. Similarly, the person who values *using time efficiently* may enjoy adding an active secondary task to a passive primary task, rescuing time that would otherwise be wasted, but may consider conducting two active tasks at once to be unpleasantly distracting and *in*efficient. Further, as suggested above, a given individual may evaluate the benefits and disbenefits of a given combination of features quite differently, depending on the time granularity: the same person who finds switching between two active work tasks to be irritating and inefficient at fine granularities, may enjoy doing so on a coarser time scale for the variety and synergistic insights that result.

Table 2
Potential motivations as a function of the nature of the multitasking combination

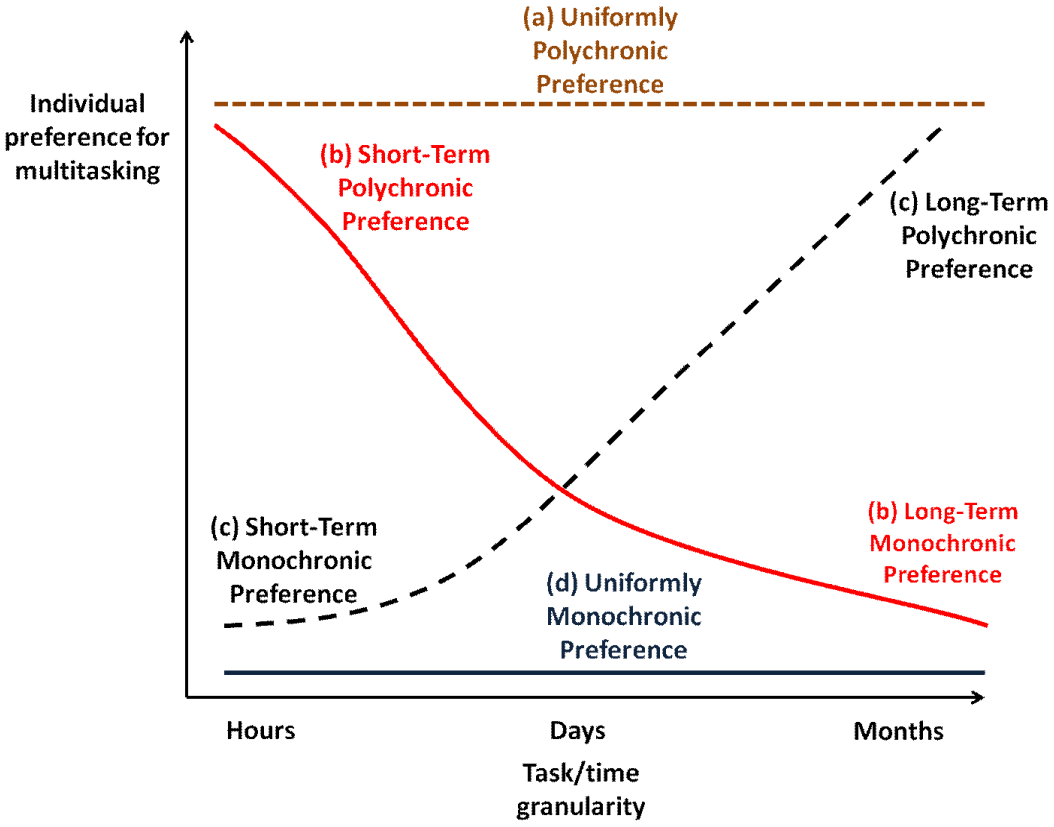
		Secondary activity	
		Passive	**Active**
Primary activity	Passive	(sec) listening to music (pri) while dinner cooks RELAXATION	(sec) working (pri) while dinner cooks EFFICIENCY
		(sec) listening to music (pri) while getting a tooth filled at the dentist AMELIORATING THE UNPLEASANTNESS OF THE PRIMARY ACTIVITY	(sec) taking photographs (pri) while on a moving train ENHANCING THE PLEASANTNESS OF THE PRIMARY ACTIVITY
	Active	(sec) listening to music (pri) while working CREATING A SUPPORTIVE AMBIENCE	(sec) reading (pri) while eating *(complementary resources)* EFFICIENCY
			(sec) checking Facebook (pri) while doing homework *(competing resources)* STIMULATION
			(sec) riding a unicycle (pri) while juggling *(competing resources)* DESIRE TO MASTER A SKILL

Note: Motivations are in CAPITAL LETTERS below each example.
Source: Own definitions.

Furthermore, we agree with Palmer and Schoorman (1999) that individuals are not dichotomously polychronic or monochronic, but rather that polychronicity is a *continuum*, measuring the *extent* to which they prefer a given type of multitasking. For these reasons, we conceptually envision the polychronicity of an individual as characterized not by a single score on an index (as it is often considered to be in the literature, and as applied in behavioral studies; Zhang *et al.*, 2005; Sanjiram and Khan, 2011), and certainly not by a simple binary tag of poly- or monochronic, but by a possible multitude or vector of continuous-valued scores representing the preferences for *different types of multitasking*. The "types" in question (i.e. the specific dimensions of the conceptual space of interest) will vary with the subject of study, and could include any of the elements discussed throughout this paper (among others): time

and task granularity, the combinations of resource types required, combinations of activity types (leisure, work), primary/secondary combinations, activity/passivity combinations, and the specific motivations or benefits and costs of the activities to be performed (e.g. the importance of the task for the individual's career; the civic responsibility associated with it; perceptions of pleasure, risk or danger associated with performing it). Beyond these intrinsic aspects of the task combinations themselves, one's expressed polychronicity preferences can also be a function of context-specific characteristics such as personal volition (Persing, 1999 – we may enjoy conducting multiple tasks on our own terms, but not on terms dictated by a supervisor or other constraints), mood (sometimes background music may soothe the nerves, and sometimes it may jangle them), and fatigue (Slocombe, 1999). We illustrate these ideas with two figures. Figure 7 presents four examples of possible continuous functions expressing an individual's degree of polychronicity in the simple case of only *one* dimension, i.e. task /time granularity[38].

Figure 7
Examples of polychronicity preference curves with respect to task/time granularity



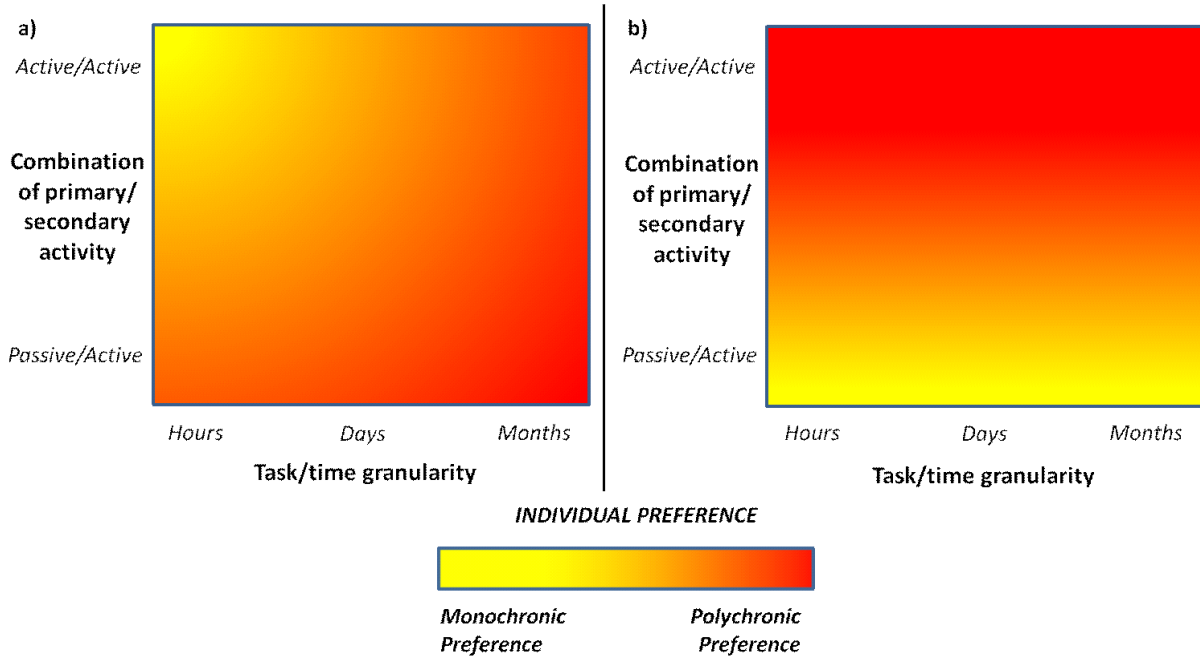
Source: Own illustration.

[38] As mentioned in Section 3, task granularity is often correlated with time granularity. In fact, unless both units are specifically defined in a study, we expect that the individual would tend to adjust the task granularity (i.e. the level of detail for the identification of "activities") in tandem with the time granularity. See Section 3 for further discussion.

The four different patterns in the figure identify some stereotypical profiles of polychronic/ monochronic individuals who exhibit rather variable polychronic attitudes depending on the level of task/time granularity involved. The individual's attitudes may vary significantly, for example, when moving from finer levels of task granularity, which are associated with detailed representations of activities measured in short time units (e.g. "answering the phone while checking email in the office"), to coarser levels of task granularity, as found for longer time periods (e.g. switching: "change job often during the year, to satisfy variety-seeking desire", or overlaying: "engage in a secondary job in addition to the primary one, to feel more personally satisfied"). In addition, in our view the level of polychronicity (or "polychronicity profile", as described in Figure 7) is not a permanent fixed trait of the individual, but rather follows a continuous trajectory that can assume different values over time, and that is affected by all the factors previously described (e.g. nature of the activity, environmental context, degree of fatigue or stress, personal attitudes and preferences and even moods or personal volition).

Figure 8 represents another possible conceptualization of polychronicity profiles, but this time derived for a *two*-dimensional construct space, where the *x*-dimension is the task/time granularity as in Figure 7, and the *y*-dimension denotes the degree to which the primary activity is passive (with the secondary activity always being active).

Figure 8
Polychronicity preference surfaces over a two-dimensional space for task/time granularity and degree to which the primary activity is passive (where the secondary activity is always considered active)



Source: Own illustration.

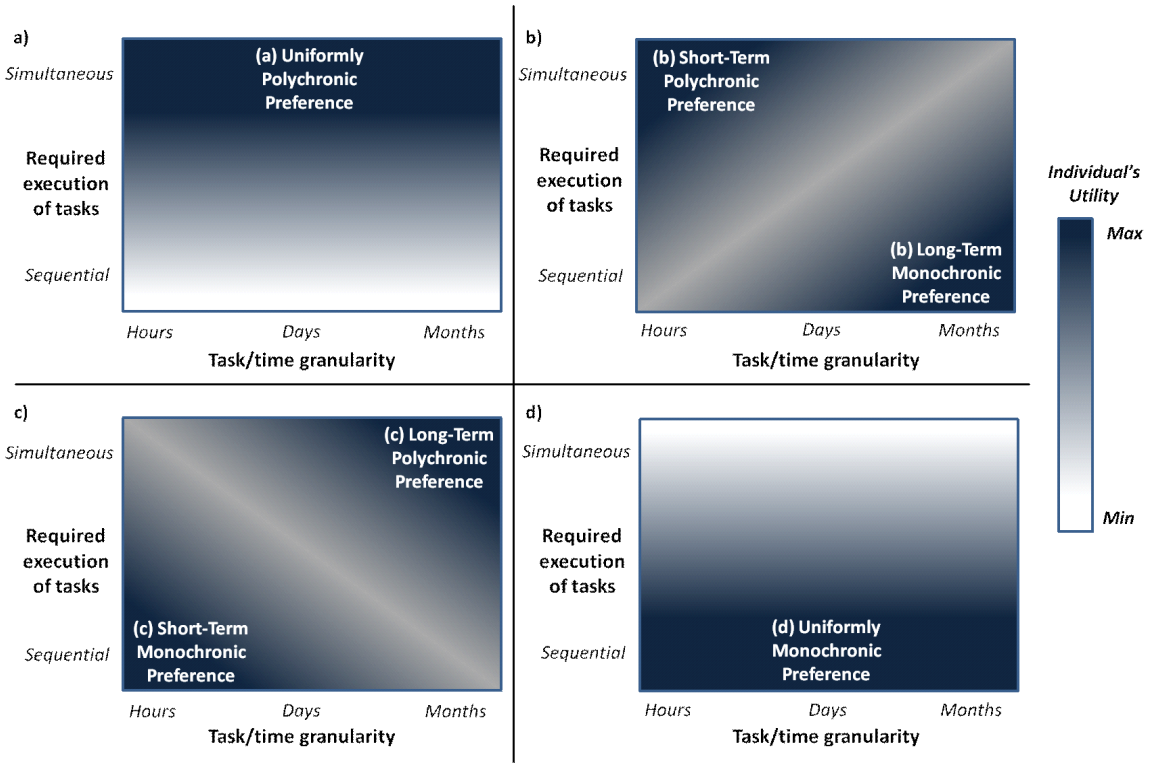
The third dimension in this figure plots the individual's preference or liking for each point on the two-dimensional plane, where we represent a greater preference for multitasking (i.e. a higher degree of polychronicity) with darker shading. Part (a) illustrates an individual who does not enjoy combining two active tasks at fine task/time granularities, but who has some propensity for doing so at coarser granularities, and who enjoys – at any granularity – combining an active secondary task with a passive primary one. Part (b) illustrates an individual – perhaps the stimulation-seeker of Table 2 – who thrives on combining two active tasks at any granularity, but who (not oriented toward efficiency) is less motivated to add an active secondary task to a passive primary one. Comparison of the two halves of the figure shows two entirely different polychronicity profiles.

Of course, obtaining measurements of polychronicity preferences over the entire two-dimensional plane will generally not be practical. In reality, we can think of systematically sampling a small number of points from a desired conceptual space (in the examples in the figure, say, four scenarios representing the four corners of the rectangle), and obtaining a preference response for those points. We could potentially add other dimensions to the space (e.g. activity purposes of work versus leisure), and systematically sample from that (hyper)cube. In this way, we would represent an individual's polychronicity not with a single value, but with a vector or *profile* of values.

At the same time, we could develop measurements of the *actual extent of multitasking* at each of the same points in the hypercube, and compare the preference (polychronicity) vector to the behavior (multitasking) vector, to more specifically understand the nature of any mismatch between them. It would then be of interest to cluster individuals on the basis of their vectors of values, to better understand the prevalence of different *combinations* of polychronic tendencies (and/or multitasking behaviors) in the population, and other variables associated with various combinations.

Further, we could assess the mismatch between a preference (polychronicity) profile and a behavior (multitasking) profile using a measure of satisfaction, or (as economists would say) *utility*. For example, Figure 9 portrays the *utility surfaces* that are obtained when individuals with the polychronicity profiles from Figure 7 are exposed to environments that involve various levels of multitasking (vertical axis) at various levels of task granularity (horizontal axis). The third dimension in this figure measures the individual's utility, where now darker shading represents a higher level of utility (in contrast to Figure 8, where it represented higher levels of polychronic preference). As shown in Figure 9, utility is higher when there is a match between the individual's polychronic/monochronic preference and the corresponding degree of multitasking in the environmental reality, and lower when there is a mismatch.

Figure 9
The individual's satisfaction (utility) varies with the degree to which her polychronic/monochronic preference patterns match the requirements for multitasking in the environment to which she is exposed.



Note: Higher values of utility are represented by darker shading (the polychronic/monochronic preference patterns are the same as in Figure 7).
Source: Own illustration.

8 Conclusions

8.1 Summary of key ideas

Multitasking is an important phenomenon that is rapidly changing many work-related and social habits in modern society. However, the subject offers a great deal still to explore, and significant levels of ambiguity remain in the terminology, in the definition of relevant variables for analyzing these phenomena, and in the way to measure multitasking behaviors and polychronic preferences. The present paper endeavors to contribute to a clarification of these definitional and measurement challenges.

In this paper, as suggested by some other authors, we refer to *polychronicity* as the "preference for doing more than one activity simultaneously", and *monochronicity* as the opposite "preference for doing one activity at a time". Multitasking is therefore the corresponding behavior in which multiple tasks are run at the same time, either *sequentially* (alternated/ switched within a relatively small amount of time), *interleaved* (partially alternating to a sec-

ond task while keeping some resources allocated to the first), or *simultaneously*. The paper organizes these possibilities into a typology of multitasking, based on the dimensions of *share of time* and *share of available resources.*

We discuss several issues relevant for empirical research. First, we discuss the existence of different domains of resource inputs that an individual can allocate to the execution of tasks. Multitasking is easier when activities require the use of resources belonging to different domains. We also note that the total amount of available resources that can be assigned to the execution of activities can vary depending on limitations on the availability of resources, and even on the presence of temporary factors that might reduce (e.g. fatigue, stress) or expand (e.g. physical fitness, or Csikszentmihalyi's mental "flow") the availability of the resources.

Second, we discuss the concept of efficiency in output (which is a function of the resource inputs allocated to task execution), i.e. the extent to which the individual's productivity under multitasking is higher than, equal to, or lower than her productivity in a monotasking condition, depending on the intensity and quality of the interactions between the activities: the presence of competing tasks that require resources in the same or different domains (e.g. mental versus physical) may significantly affect the efficiency with which activities can be carried out by an individual.

Third, we discuss issues relating to the time granularity (level of detail) used to classify and record activities, and the time period of observation, which are often ambiguous in previous work in the literature. Both issues affect the definition of multitasking (and of polychronicity), with for instance the time granularity completely changing the perception of the simultaneity of activities if assessed over one hour of work versus over one week.

Fourth, we address how activities can be categorized according to their natures, such as whether they are active vs. passive, or primary vs. secondary. Several different definitions related to these concepts are often adopted in empirical studies. We propose the working definition of primary activity as "the one you would be doing anyway". Similarly, the activity/ passivity of a task is defined as a continuum and depends on the share of resources and the need for attention (compared with tasks that "run in the background", which are correspondingly passive) that is associated with the execution of that task. We discuss the special roles of travel and waiting as transitional activities often conducted in a multitasking modality.

Fifth, to illustrate the wide variety of behaviors that can be considered multitasking, a library of examples of multitasking combinations is presented. The combinations are classified based on the purposes of the primary and secondary activities (focusing on five major categories of mandatory, personal/domestic care, leisure, shopping, and travel), and whether the primary activity is active, passive or waiting.

Finally, we discuss the measurement of polychronicity as a specific individual trait. It is the authors' opinion that polychronicity can be usefully viewed as a time-dependent vector-valued construct rather than a single-valued scale measurement. Polychronic attitudes may

depend, for example, on the time and task granularities with which activities are measured, the resource combinations required, or whether a given task is active or passive. An individual may present a complex preference surface as a function of time, the nature of the activity, and the specific context in which polychronicity is measured. We present some graphical examples of possible preference surfaces, as well as an example of a utility or satisfaction surface illustrating the mismatch between an individual's preference and the reality of her environment.

8.2 Perspectives for future research

In this paper, we have examined a number of current issues that have limited the ability to explore in full depth the multifaceted nature of multitasking and the complex factors that combine to generate individual preferences for multitasking, i.e. polychronicity. The study offers many ideas for further research, and it is our hope that the concepts set forth in this paper will stimulate the research community to continue to refine and operationalize them in a way that will improve our understanding of this ubiquitous and consequential phenomenon.

Among the topics that can lead to future research activities in this field, we believe that additional efforts should be spent to further improve the definition of the resource types associated with the execution of activities and tasks, the appropriate metrics by which to characterize them, and the knowledge of how various types can and cannot be combined when performing activities in any of the various forms of multitasking. We need similar refinement of output metrics and measurement of output efficiency under various multitasking scenarios. Similarly to the way the human body undeniably engages in multiple *internal* physiological activities simultaneously, we need to better understand the types of *external* tasks that can also be conducted simultaneously, at even the smallest time granularities. To that end, a fascinating frontier would involve the development of a library of functional magnetic resonance images (fMRIs) of the brain, under a systematic set of multitasking examples along the lines of our descriptive library discussed in Section 6.

An important field to explore is the investigation of *why* people engage in multitasking activities, in different contexts and at different time granularities. Although there have been a number of studies relating general measures of polychronicity to various personality traits (e.g. Conte and Gintoft, 2005; Frei *et al.*, 1999; Mark *et al*., 2008; Persing, 1999), in fact we know relatively little about the assorted *reasons* for which people engage in multitasking (Cotte and Ratneshwar, 1999), and how those reasons relate to different personality traits as well as to various multitasking combinations.

In general, it is a non-trivial research challenge to find better ways to obtain information on when and how people multitask and how satisfied they are with it, depending on the environmental context in which the activities need to be carried out, the purpose of each activity, the time scale at which activities are measured (time/task granularity), and the motivation behind their multitasking behavior. One approach may be to develop applications for the mobile

phone and/or other handheld devices that will facilitate the real-time collection of such data, as is currently happening on the frontiers of physical health (Doherty and Oh, 2012), mental health (Reid et al., 2009), travel behavior (Girardin et al., 2009), and time use (Sonnenberg et al., 2012; Merz, 2009) research. Another approach could involve using the power of online surveys to choose questions customized to the individual, based on his responses to earlier questions. Yet another approach could involve using conventional surveys, but simply to narrow the field of study to a more specific environmental context and/or a more manageable set of activity combinations. Our hope is that the classification dimensions presented in this paper will provide guidance on how to do this in a more purposive way.

Finally, future research should also focus on fleshing out an individual's *profile* of polychronic preferences. We envision this profile to be constructed by systematically sampling scenarios from the hyperspace of interest to the particular study (see Section 7), and obtaining the individual's preference for each scenario. An initial aim would be to test the hypothesis that different individuals might exhibit different degrees of polychronicity depending on context and personal variables such as the nature of the activities to be performed, both singly and in combination; the environment in which they are performed (work, social, etc.); the types of resources that are required to perform such activities; the time horizon over which the activities are conducted; and the type of multitasking form (e.g. switching vs. overlaying) that would be required (in addition to personal attitudes, preferences and tastes). Presuming that hypothesis is supported, it would then be natural to cluster individuals on the basis of their polychronicity profiles, and begin to explore the associated characteristics and implications (e.g. for work productivity and satisfaction) of various profiles.

All told, it seems that we know very little about how complex a single individual's polychronicity preference surface might be, let alone the vast diversity in such surfaces across a population. The immense landscape of multitasking/ polychronicity remains largely unmapped, and invites considerable further exploration.

Appendix A – Metamorphosing among multitasking types

The four types of multitasking shown in Figure 1 differ along two dimensions. With respect to the vertical dimension, let r_{A1} refer to the *share of resources* allocated to activity A during time interval T_1 (i.e. the initial configuration in the two-dimensional space for *time* and *resources*), which is simply the height of the shaded portion in the left-most section of each rectangle in the figure. r_{A1} may vary between 0 and 1 (inclusive), while the remaining share of resources available during the same time interval T_1, $r_{B1} = 1 - r_{A1}$, is allocated to activity B. Consequently, with respect to the horizontal dimension, T_1 refers to the *share of time* during

which the initial configuration associated with the share of resources r_{A1} and r_{B1} is maintained before moving to a new configuration with r_{A2} and r_{B2}.

Following the classification in Figure 1, the *monotasking* archetype (M) is the one in which a single activity A occupies full resources for the full block of time (r_{A1}=1, T_1=1). In the *switching* archetype (S), a given activity A occupies full attention for only part of the time in which activities are observed, while resources are allocated to the following activity B for the remaining amount of time (r_{A1}=1 and r_{B1}=0 for $0<T_1<1$; then r_{A2}=0 and r_{B2}=1 until the end of the period of observation). For *interleaving* (I), both activities occupy some resources at all times, although the allocation of resources between the two activities *fluctuates* over time (the initial configuration r_{A1} is mantained for the time T_1 before moving to the configuration r_{A2}, with both $0<r_{A1}<1$ and $0<r_{A2}<1$, and $0<T_1<1$). In *overlaying* (O), by contrast, both activities occupy some attention at all times ($r_A>0$ and $r_B>0$ at any time) *without* significant fluctuation in the allocation of resources across time. In this case, both activities are carried out at the same time, with a substantial "parallel" allocation of resources ($0<r_{A1}<1$, T_1=1).

Figure 10 illustrates the relationship between the four basic archetypes of *monotasking*/ *multitasking* presented in Figure 1, along the two dimensions of *disparity in the allocation of resources* (r_{A1}-r_{A2})[39] and *share of time*. The *monotasking* (M), *switching* (S), *interleaving* (I) and *overlaying* (O) archetypes occupy the four corners of the top-right box in the figure. The remaining cells in Figure 2 show how each archetype can metamorphose into each of the other ones, by varying the differences r_{A1}-r_{A2} in the vertical direction, and/or the time T_1 in the horizontal one. Interestingly, overlaying can be achieved in two ways: along the horizontal dimension (left to right), by increasing T_1 to 1 (i.e. increasing the time during which a specific allocation of resources between A and B is maintained, to comprise the entire interval), or along the vertical dimension (top to bottom), by reducing r_{A1}-r_{A2} to 0 (i.e. by reducing to 0 the temporal disparity in resource allocation to A, converging to a constant allocation of resources to A across the entire interval). Similarly, it is possible to converge to switching via each dimension: horizontally from monotasking, at the instant that T_1 decreases from 1, or vertically from interleaving (when $0<T_1<1$), as the difference r_{A1}-r_{A2} increases from 0 (the overlaying special case) to greater than 0 but less than 1 (interleaving), or to 1 (switching). Naturally, continuous variations on the examples in the figure are possible.[40]

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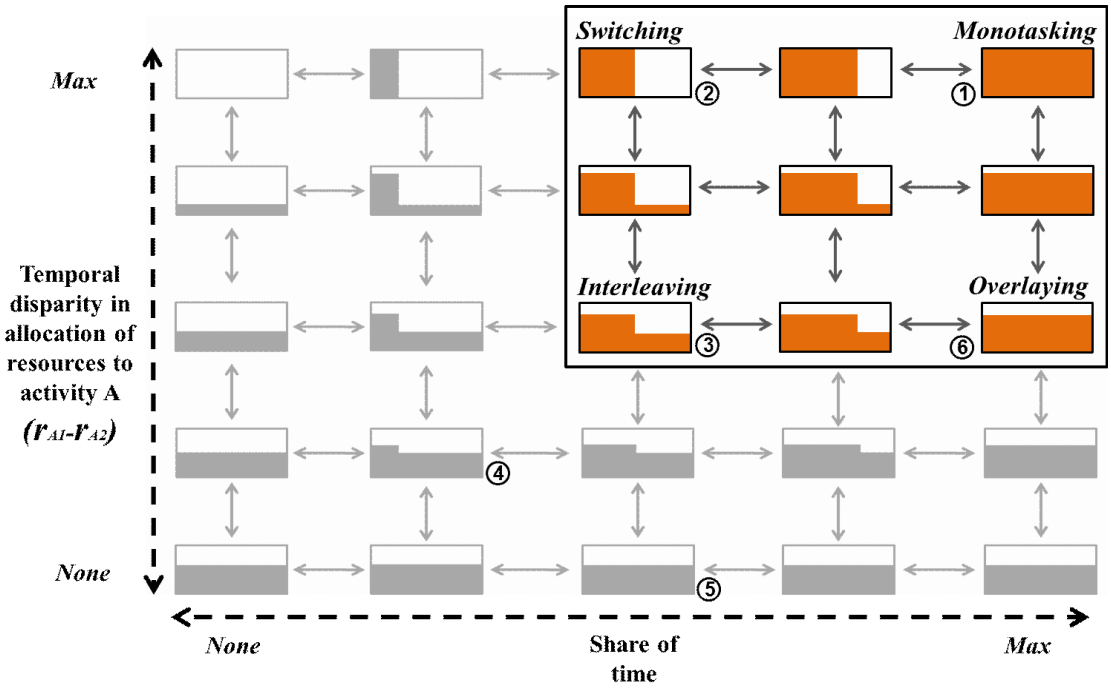
[39] In reality, the *separate* dimensions r_{A1} and r_{A2} (each taking on values between 0 and 1) identify the exact patterns of allocation of resources over time (the values of r_{A1} and r_{A2} determine the disparity r_{A1}-r_{A2}, which can range between -1 and 1). To simplify the graphical portrayal and the accompanying discussion, we here collapse those two dimensions into one by focusing on r_{A1}-r_{A2} (and only the range from 0 to 1, relying on symmetry), which, as Figure 10 illustrates, is what determines the *multitasking classification* of a given pattern.

[40] For more complex situations involving more than two activities and longer units of time, the information-theoretic concept of "entropy" (disorder, uncertainty) may offer a useful means for quantifying and classifying activity patterns (see Yeung, 2002 for an introduction, and Leslie *et al.*, 2007 for a spatial application; and although the authors did not employ this concept, entropy could also be used to characterize the temporal fragmentation of activities in Alexander *et al.*, 2011).

Figure 10
Metamorphosis of multitasking and monotasking configurations, depending on the share of available resources allocated to the execution of a task (and the temporal disparity in their allocation over time) and share of time



Source: Own illustration.

Appendix B – One activity, or two?

Constructing the library of Section 6 highlighted an occasional difficulty in identifying whether an example constituted two activities (as we desired), or one activity fulfilling two purposes (as we tried to exclude). For example, we struggled with whether "entertaining business clients while on a cruise ship" ("work (A) travel") constituted two activities, or whether the entertainment were an integral part of the cruise. We concluded that either activity *could* be "*intactly*" conducted without the other, and thus allowed it to qualify as two activ-

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The amount of entropy possessed by a random discrete distribution is defined as $-\sum_i p_i \log_b p_i$, where p_i is the probability of outcome "i" occurring, and $\log_b$ is the logarithm function using base b. Entropy is maximized ("information" is minimized) when probabilities are equal, and minimized (information maximized) when probabilities are extreme (0 or 1). In our context, the p_is are the shares of resources (r_{A1} and r_{B1}; r_{A2} and r_{B2}) and shares of time (T_1 and 1-T_1), and thus we can refer to entropy in resources and entropy in time, where "greater entropy" corresponds to "more equal shares". Figure 2 shows, for example, that moving left-to-right horizontally, from interleaving to overlaying or from switching to monotasking, involves first increasing (up to T_1 = 0.5) and then decreasing the entropy in time.

ities. On the other hand, we avoided cases in which one (secondary) activity is *instrumental* to conducting the other (primary), such as driving around to look at outdoor Christmas decorations in a certain neighborhood (in which travel is necessary to conduct the primary activity of looking at Christmas lights). We differentiate that example from enjoying the scenery while riding the train to work (which would be allowed, although it does not appear in the table), however. In the latter case the scenery-gazing (secondary) is *incidental* to the primary activity of travel (even if for some people it constitutes an important factor in their choice of mode and/or route): some people may ride the same train and hardly look out the window at all, whereas the *entire point* of going for a drive in the decorated neighborhood is to look at the scenery.

The issue of whether a single activity fulfills two purposes also relates to the question of what constitutes an *activity*. If an individual goes to a party and dances while nibbling on hors d'oeuvres, listening to music, and talking to friends, is she multitasking, or simply conducting the activity "party"? Time and task granularity (Section 4) is clearly one dimension of the question, but another (related) dimension is the extent to which a certain aspect constitutes a *characteristic of an activity*, as opposed to a *separate activity in its own right*. This issue especially seems to arise in the context of socializing with friends. Is going to the ball game with friends one activity, or two (going to the ball game, socializing with friends)? How can we articulate the distinction between this case and one in which two activities are clearly unconnected (reading the newspaper while eating breakfast; listening to music while working)? Our working distinction (although not a perfect one) is that in the former situation, taking one activity away materially changes the way the other would be conducted. Thus, "relationship-building while accompanying a business associate on an excursion" ("work (P) travel") is, from one perspective, a single activity fulfilling two purposes (work and travel). But from another perspective it is two activeties (relationship-building and travel) overlaid, either of which could have occurred without the other, but for which doing either without the other would have changed its nature. From this point of view such situations are of interest for studies that investigate the propensity of individuals to engage in simultaneous activities as a way to increase their personal utility or as a preferred scheduling strategy.

Weaving this discussion together with points and examples discussed previously suggests that groups of activities can be placed along a rough continuum, based on the degree to which separate activities are distinct or distinguishable. Table 3 summarizes the points along this continuum that have been discussed in this paper. Taking the broad view, the entire continuum can be considered to constitute multitasking, but specific studies may wish to exclude some portions of it when analyzing specific research contexts.

Table 3
A continuum of the degree to which multiple activities are distinct/ distinguishable

	Description	Example(s)
greater distinguish–ability ↓	a single activity fulfills multiple purposes	bicycling to the store for both transportation and exercise
	one activity is inescapably *instrumental* to the accomplishment of the separate primary activity	viewing the Christmas decorations is primary, riding around to do so is instrumental
	a bundle of (sub)activities is integrally related to accomplishing a single task (largely a matter of granularity)	both viewing the scenery *and* the experience of riding in a hot-air balloon are integral to the accomplishment of the joyriding task
		thinking, reading, typing in order to write a paper
	one activity is *incidental* to the accomplishment of the primary activity	riding the train to work is primary, viewing the scenery while doing so is incidental
	two conceptually distinct activities are connected and/or planned together	getting together with friends, going to the ball game
	two activities are entirely unconnected	reading while eating; listening to music while working

Source: Own definitions.

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Paid and unpaid work in Denmark – Towards gender equity

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Abstract

Since the 1960s women in most countries have increased the time they spend in the labour market, while little change has been seen in their time spent on unpaid household work. Men, however, have decreased their labour market participation and increased their time used on unpaid household work. This trend also holds true for Denmark, albeit reduced by standardization for the demographic distribution. The most robust result is a continued convergence in women and men's time use. When making a linear projection of the trends in women and men's time use, we have to go to the year 2033 before Danish women and men spend an equal amount of time in paid employment. However, for household work, gender equality will arrive as early as 2023.

JEL-Codes: D12, J2

Keywords: Time use survey, inequality

1 Introduction

In recent decades the distribution of paid and unpaid work between women and men has been on the political agendas of most developed countries. In their seminal work, Young and Willmott (1973) showed that around the mid-1960s every time women in the London region took on an extra hour of paid work, they were relieved of only half an hour of unpaid work. The UN (Goldschmidt-Clermont and Pagnossin-Aligisakis, 1995) also conducted an important investigation of how much paid and unpaid work women and men undertook in various countries worldwide.

Gershuny (2000) argues that the development up to the 2000s can be characterised by three major convergences in time use: *between countries, between women and men, and between social classes.* These convergences are said to be the result of globalisation, understood as technological, cultural and economic globalisation ensuing from increased intercourse and reciprocal influence among countries. As a consequence of the ongoing liberalisation of international trade and the free movement of capital, governments and the private sector have been obliged to pursue more or less identical economic policies, including labour market policies with many features in common. Nevertheless, the convergence has not removed all differences inasmuch as men clearly continue to have more paid work than women do, and women clearly have more unpaid household work at home.

Nonetheless, women have experienced a development towards more paid work and less unpaid work, which has enabled them to earn higher incomes and to improve their social standing. Bonke (1995) contains an overview of 30 years' developments in work opportunities and time use in OECD countries and concludes, like Gershuny (2000) five years later, that women and men's time use is converging and ascribes much independent importance to education: “For women a high level of education has been an important factor in the trend towards greater and more lasting participation in the labour market” (ibid. p. 9). And there is a clear link between a high proportion of women with further education and high employment frequency.

In Sevilla and Giminez-Nadal (2012) and Kan et *al.* (2011) the convergence remains when the researchers analyse cross-national trends in paid and unpaid work and the distribution of these activities between women and men over the past 40 years. But the trend is now moving more slowly, and, as Kan et *al.* remark, "incompletely". According to a simple projection, we shall have to wait 70–80 years until women and men quantitatively have the same amount of working time inside and outside the home, albeit there are differences depending on the welfare systems in the countries concerned.

To analyse these circumstances in more detail, Gershuny and Kan (2012) and Kan, Sullivan and Gershuny (2011), for example, take their departure in Esping-Andersen's division of modern welfare states into three prototypes: the liberal, the continental and the Scandinavian (or social-democratic) models (Esping-Andersen, 1990). They investigate whether there is a

systematic association between women's time use on child care and routine housework in countries belonging to the three different models, here expanded with a fourth: the southern European or residual model (Esping-Andersen, 1999). The result is that it is possible to find a causal association of this kind since the Scandinavian model with its highly developed network of day-care institutions seems better able to facilitate equality between women and men in their use of the 24 hours of the day than do the other models.

In the following we look specifically at trends over 45 years in paid work and household work in Denmark, which represents a Scandinavian welfare society, which has hitherto only been included in international comparison with figures until the late 1980s (Gershuny and Kan, 2012). Thus we are looking to see when the modern "Hundred Years' War" will crystallize in identical time use by women and men, concluding our study with a projection based on trends in Denmark.

2 Data – 45 years with Danish time use studies

To describe the major trends in the Danish population's time use, we used data from nationwide and representative Danish surveys, which in many respects follow the time-use survey guidelines developed by Eurostat (2000) and are all based on probability samples, see Bonke (2012) for further information on the Danish surveys. The surveys all include diary information on several activities performed on randomly chosen weekdays. The developments in household work and leisure are connected with some uncertainty because these activities have not been registered with the same degree of detail over time. The definition of paid and unpaid work used here is:

- Paid employment: work in main occupations and sideline occupations along with banked overtime, but not transport to and from work.
- Unpaid/household work: shopping, housework, DIY and child care.

In relation to other registrations it is important to note that we refer only to the spring months in the years in question as up to and including 1987 the surveys cover only these months. This is the reason why the number of respondents is relatively low for 2001 and in particular for 2008–09. Furthermore, we include diary information for interview persons only, not for their family members.

The surveys referred to are from 1964, when the Danish National Centre for Social Research undertook its first survey where 3500 visit interviews were attained; from 1975, when the Centre carried out a new survey based on approximately 3700 visit interviews; and from 1987, when the third nationwide survey was conducted, see Andersen (1987; 1988). All surveys contain a 24-hour rhythm schedule in which respondents are asked to state the activities they were involved in during a selected 24-hour period from 4 a.m. the first day until 4 a.m. the next day. The next time use survey was conducted in 2001 and included visit interviews with 2739 persons, who together with their cohabiters, if any, completed 6518 diaries record-

ing their time use (Bonke, 2002). Lastly, in 2008–09 the time use survey in Denmark was carried out by the Rockwool Foundation Research Unit (Bonke and Jensen, 2012; Bonke and Fallesen, 2010). Besides the representatively selected respondents, their partners and any children between the ages of 7 and 17 years were asked to complete 24-hour rhythm schedules for the same weekdays, which brought the number of completed schedules up to 16,802: weekdays and weekend days taken together. However, because the surveys for the years 1964, 1975 and 1987 refer to interviews in February and March, the interviews for 2001 and 2009 cover interviews for the same months, i.e. 2001 covers interviews also for March, and 2009 covers interviews also for January. This reduces the number of interviews for the two last years to 715 and 77, respectively, while there are 3057, 3273 and 3438 interviews used for the previous years. The response rates for the surveys were 66.6, 72.7, 64.6, 65.8 and 77, respectively, and all data are weighted by age, gender and marital status to make the datasets representative for the Danish populations in the different years.

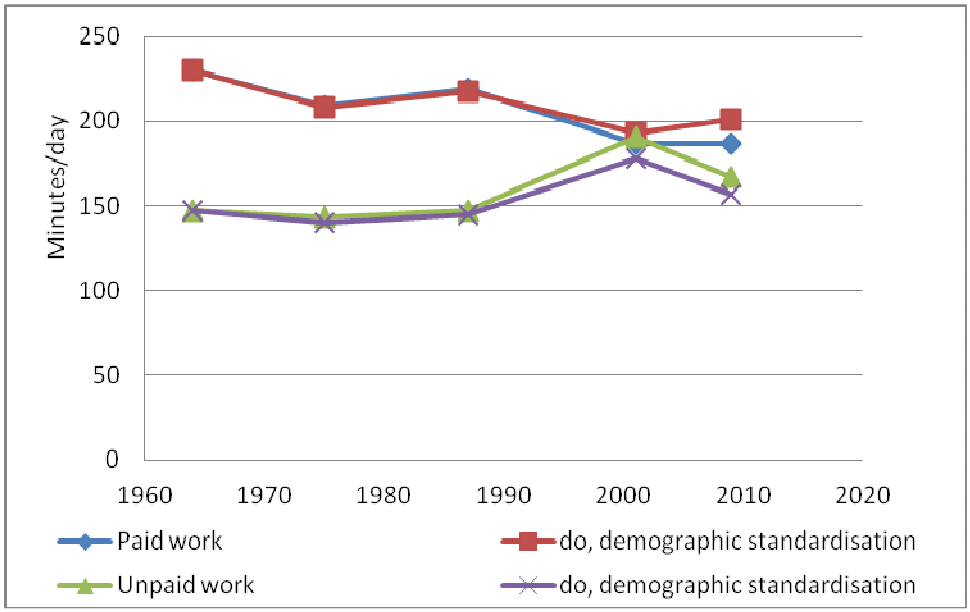
In contrast to Aguiar and Hurst (2007) and Sevilla and Gimenez-Nadal (2012), who restrict their samples to individuals between 21 and 65 years of age, we use the broader age span of 18–74 years. This is because many younger and older Danes were occupied on the labour market in the 1960s and 1970s, with elderly individuals seemingly remaining there longer, allowing us to focus on the development of societal labour supplies measured as individual averages for the adult population over the last 45 years. However, we also use a subsample of employed men and women to see whether the trend in all 18-74-years olds' paid and unpaid work can be ascribed to time-use changes within this group.

3 Developments in the Danish population's paid and unpaid work 1964–2009

It appears from Figure 1 and Table 1 that during 1964–2009, if we take the actual time worked and exclude time commuting, there has been a general fall in the hours worked by Danes in the labour market. If we look at the hours worked on an average weekday in the different periods, we can see that in 1964 this was 3 hours 50 min against 3 hours 29 min in 1975 and 3 hours 39 min in 1987. Later, in 2001 and 2009, the time worked was down to 3 hours 7 min. Thus, it was in the periods 1964–1975 and 1987–2001 that working hours fell, more precisely, by just under 2½ and ¾ hours a week, respectively, a total fall from 1964 to 2009 of almost 20%.

While the decrease in working hours during 1964–75 took place at the same time as negotiated reductions in working hours in the labour market from 44 hours a week in 1960 to 40 hours in 1974, the fall from 1987 to 2001 occurred in a period in which the negotiated working time was reduced from 39 to 37 hours a week. Longer holidays were also introduced in the course of these periods, but this is presumably reflected in the figures only to a limited extent as we look solely at activities in the spring months.

Figure 1
18–74-year-olds paid and unpaid work on an average weekday 1964- 2009. Standardised for demographic changes (gender and age)



Time use forward in time is standardised with departure in Denmark's demographic (age and gender) distribution in 1964. See notes in Table 1
Source: Danish Time Use Survey 1964 -2009, own illustration.

For household work, we find that it was more or less constant during 1964–1987, after which it rose up to 2001 and then fell until 2009, albeit without returning to the levels of the 1960s, 1970s and 1980s. In 2009, 2¾ hours were spent on household work on an average weekday as opposed to just under 2½ hours up to 1987. The substantial rise in household work of 45 min per day, or 5 hours per week, during 1987–2001 is surprising even though it occurred precisely at the time when there was a decrease in hours worked in the labour market and thus a change in where Danes were working—more at home and less outside the home—see also Bonke (2002).

The unchanged extent of household work during 1964–1987 and the later increase are noteworthy considering the increased availability of more highly pre-processed foods, fast food, effective cleaning agents and timesaving household appliances. There are, therefore, indications that production simply increased—clothes washed more frequently, larger homes, more dishes at meals and more time spent on child care—thereby more than "counter-balancing" the productivity gains, and that do-it-yourself had replaced paid work at home and also to some extent outside the home, cf. Gershuny (1978; 1979).

In Table 1 the trends for paid work and unpaid work have been calculated as the 10-year changes in time use over the entire period 1964–2009. It can be seen that the decrease in paid working time corresponds to 9½ min per day or a little more than an hour a week for each decade. This trend is partly counterbalanced by the increase in household work of 8 min per day, or just under 1 hour per week. This leaves room for a slight increase in leisure time corresponding to just under 4 min a day, or 30 min per week per decade. However, it is not cer-

tain that leisure time has increased at all as the figures are not statistically significant (not shown in table 1).

Table 1
Women and men's paid work[1] and unpaid work[2] on an average weekday 1964–2009. 18–74-year-olds

	1964	1975	1978	2001	2009	Trend 1964-2009
			Hours: min/av. weekday			Min./day/10 years
			Employed and non-employed Men			
Paid work	5:54	4:43 *	4:32 *	3:56 *,a	3:49 *	-25.67 α
Household work	0:29	1:11 *	1:40 *,a	2:30 *,a	2:17 *	25.97 α
			Employed and non-employed Woman			
Paid work	1:46	2:12 *	2:47 *,a	2:24 *,b	2:28 *	8.03
Household work	4:24	3:39 *	3:12 *,a	3:47 *,a	3:15 *,a	-10.70
			Employed and non-employed Men and Woman			
Paid work	3:50	3:29 *	3:39	3:07 *,a	3:07 *	-9.48 α
Household work	2:27	2:23	2:27	3:11 *,a	2:47 *,a	8.15 β
			Employment rate			
Men	81,3	74,4	67,1	60.2	65.4	-4.07
Woman	27,7	47,0	57,8	49.2	53.3	4.53
Men and Woman	51.5	60.0	62.6	54.4	59.1	0.74
			Hours: min/av. weekday			Min./day/10 years
			Employed Men			
Paid work	6:42	6:02 *	5:48 *	5:34 *	5:33 *	-14.34 β
Household work	25	1:01 *	1:31 *,a	2:20 *	1:54 *,a	22.68 β
			Employed Woman			
Paid work	4:49	4:19	4:24	4:17	4:06 *	-8.22
Household work	2:20	3:04 *	2:54 *	3:22 *,a	2:59 *	5.58
			Employed Men and Woman			
Paid work	6:11	5:23 *	5:10 *	4:57 *	4:48 *	-16.50 β
Household work	56	1:48 *	2:09 *,a	2:50 *,a	2:26 *,a	21.18 β
No. of observations	3057	3273	3438	715	777	…

*significant difference at 0.05 level in relation to 1964.
a,b significant difference at 0.05 or. 0.1 level respectively in relation to previous year.
α , β significant difference at 0.01 or 0.05 level in relation to 0: no change in the period.
[1] Paid employment includes work in main occupations and sideline occupations along with banked overtime, but not transport to and from work.
[2] Household work includes shopping, housework, DIY and child care.
Note: All data are weighted by age, gender and marital status.
Source: Danish Time Use Survey 1964 -2009, own calculations.

The trends for paid and unpaid work are affected by changes in labour market attachment rates as well as by the development in part-time and full-time work. Since 1964 the labour

market participation rates have decreased from 52 to 59 in 2009 for men and women taken together with a decrease for men from 81 to 65 and an increase from 28 to 53 for women (Table 1). For the employed, the 10-year change in paid work over the entire period 1964–2009, the trend, corresponds to 16.5 min less per day, while unpaid work increased by 21.2 min per day. This implies that the decrease in paid work found for all 18–74-year-olds is caused by a smaller number of men working still fewer hours, while the increase in unpaid work for all 18–74-year-olds is caused by employed as well as non-employed men nowadays spending significantly more time on this activity, i.e. the same trend for employed and for all people within the age-group.

4 Correction for demographic changes 1964 - 2009

As age and gender are demographic factors that affect how people allocate their time, the data in Figure 1 are adjusted to reveal changes in behaviour over the period, see Aguiar and Hurst (2007) and Sevilla and Gimenez-Nadal (2012), who apply the same weighing procedure. We also calculated the impact of changes in civil status—there are more singles nowadays—although this is not to be considered a demographic factor, and the results were nearly of the same size as when correcting only for changes in age and gender distribution over time. That corrections have not been made for changes in the share of the population of non-Danish origin, immigration, is because these citizens have participated relatively little in the surveys, which for statistical reasons alone means that a correction would be problematic. The figure shows how time use during 1975–2009 would have looked if the age composition of the population and distribution by gender in each of the survey years had been the same as in 1964.

Comparison of the curves in Figure 1 shows that it is not until 1987 that the demographic changes can be seen to bring about changes in the time spent on paid employment and household. For paid employment, the daily average time spent working would thus have been 6 min longer in 2001 and 14 min longer in 2009 if the population had been demographically similar to that in 1964. Conversely, the decrease in working hours would therefore have been smaller, corresponding to 45 min less time spent working per week per decade during 1964–2009 and not more than 1 hour as, according to our calculations for the actual composition of the population, it decreased.

For household work, it is also in the most recent decades that the changed demographic composition of the population has made itself felt. In 2001 household work would thus have been 13 min shorter, and in 2009, 10 min shorter if the demographic composition had been as in 1964. Instead of an increase in household work of just under 1 hour per week per decade, the increase would have been only 38 min. Accordingly, there is no doubt that demographic changes have contributed to the fact that today Danes spend less time on paid employment and more on household work than 45 years ago.

5 The gender perspective in time use trends

If we return to actual developments and distinguish between women and men's time use, we find that while men's working hours in the labour market have decreased since 1964, women's have risen (Table 1). Thus, the trend has been that men on average reduced their working hours each decade by 26 min during 1964–2009, and women increased their working hours by 8 min each decade, although not significantly. While we can see a more or less gradual fall in men's working hours between 1964 and 2009 when we look at the individual periods, for women a gradual increase can be registered until 1987, after which their working hours fall until 2001 and then become stable in the present century. This means that whereas men worked almost 4¼ hours more than women in 1964 on an average weekday, the difference was down to just under 1½ hours in 2009. Looking exclusively at employed men and women, we find as already mentioned a decrease for men from 6 ¾ to 5 ½ hours and from 4 ¾ to 4 hours for women (Table 1). Calculated as a trend over the entire period 1964–2009, we find that the reduced gap between all 18–74-year-old women and men's time spent on paid work can be explained by a smaller difference in their labour market participation rates and a significant reduction in participating men's working hours.

For household work, the picture is the opposite of that seen for paid employment. Here it is men who have increased their contribution, while women have reduced theirs, although not proportionally. Men's daily household work has increased by what corresponds to 26 min a day in each decade as opposed to a non-significant reduction for women of only 11 min. In 1964 the difference between women and men's household work was just under 4 hours against 1 hour a day in 2009. For employed men and women we find that unpaid work increased by 1 hour and 29 min per day for men and 39 minutes for women during 1964–2009. However, only for men was the change significant when calculated as a trend for the same period; furthermore, the change was nearly the same size for employed and non-employed men taken together.

For both genders – employed and non-employed – the increase in work in one area has been more or less counterbalanced by less work in the other area, so that for both women and men the number of waking leisure hours has remained almost unchanged throughout the entire observation period. This is in accordance with that found for other industrialized countries from the 1970s until today, see Aquidar and Hurst, 2007, who looked at 21–65-year-old employed and non-employed men and women.

The trend described here towards greater equality between women and men can partly be ascribed to women's better education and an increased orientation towards the labour market and partly to a widely held wish for greater equality between women and men, both inside and outside the home.

6 Towards gender convergence in Denmark

If we try, despite uncertainties, to make a simple linear projection of the trends in 18-74-years old women and men's time use, we have to go to the year 2033 before women and men spend an equal amount of time in paid employment. For household work, gender equality arrives as early as 2023. For Norway a projection of the trends based on official statistics (Vaage, 2012) implies that women and men will also spend the same amount of time in paid work in 2033, while this happens already in 2021 for unpaid work. If the projections for Denmark were based on other functional forms better fitting the curves than the linear ones, gender equality would be reached at nearly the same times as by using the present form. However, it is important to stress that these projections are not based on forecasting taking future demographic changes or changes in marital status, number of children, etc. into consideration, which is legitimized by the very short time horizon dealt with here.

To investigate the decreasing impact of gender on time spent on household work, we also performed a series of regression analyses for the different survey years under consideration. Hence, if we include age, civil status, number of preschool and school children and number of working hours in the labour market in an analysis of the variation in the extent of household work—an implicit demographic and socioeconomic weighting—we find that this helps to explain an ever-smaller part of the variation in household work over the past 45 years (Table 2). From an explanation of the variation of 0.56 (qui^2) in 1964 the explanation falls markedly up to 1975 (0.37) and again up to 1987 (0.27), after which it becomes stable at this level.

The most important explanation for the ever-smaller part of the variation is that gender means less than it has done for the differences in the amount of household work. In 1964 the difference in women and men's household work was 240 min (4 hours) a day falling to 134 min (2¼ hours) in 1975 and to 72 min (1¼ hours) in 1987. In 2001 the difference was only 63 min (1 hour) and in 2009, 46 min (¾ hour) a day.

There is thus no doubt that seen in isolation, gender is of ever-decreasing importance for how much time women and men spend on household work. There are, however, other factors that continue to play a considerable role. For example, having a pre-school child, which seen in isolation meant 1 hour's more household work in 1964 against 1¾ hours in 2009. Schoolchildren also occasioned more household work in 1964 than in 2009—½ hour against ¾ hour—while, conversely, entering into a pair relationship "costs" less today—¾ hour against ½ hour daily. However, the impact of age has been increasing, which indicates that differences between older and younger age groups in time spent on household work are now greater than in earlier periods.

As could be expected, there is substitution between paid employment and household work. The more one works in one place, the less one works in the other. However, this was not the case in 1964, when there was a positive relation between the two types of work, which may be due to some having been very busy in both areas in order to support their families: i.e. the positive relation was found only for men (+.173), while it was negative for women (+.173 -

.259 = -.086). Nevertheless, this does not alter the fact that for women in general, paid employment has had a greater impact on their household work than is the case for men. The so-called interaction variable gender*working hours was thus negative, but decreasing in value up to 1987, after which it was no longer significant. This means that the number of working hours is no longer of greater importance for the amount of household work, or vice-versa, for women than for men, cf. Table 2.

Table 2
Unpaid/household work – min/average weekday – and different socioeconomic factors. 18–74-year-olds 1964-2009

	Household work[1]				
(ref. group)	1964	1975	1987	2001	2009
	OLS-regression coefficients				
Gender (man)	240.4***	134.5***	72.49***	63.37***	46.39***
Working hours	0.173***	-0.061*	-0.150***	-0.219***	-0.181***
Gender* working hours	-0.259***	-0.099***	-0.0439*	-0.0576	-0.0433
Age	0.131	0.506**	0.458**	1.716***	1.451***
Youngest child <7 (no children)	62.24***	40.48***	73.28***	79.25***	109.0***
Youngest child 7-17 (no children)	28.88***	45.03***	39.26***	34.07**	48.60***
Couple (single)	48.06***	43.34***	23.57***	18.26	35.06***
Constant	-142.7***	-132.6***	4.346	94.71***	64.26***
Adj. R^2	0.56	0.37	0.27	0.31	0.27
No. of observations	3056	3271	3187	715	776

[1]excl. dropping off and fetching children, visits to public and/or private institutions and gardening.
*,**,*** significant at 0.05, 0.01 and 001 levels.
Source: Danish Time Use Survey 1964 -2009, own calculations.

7 Conclusion

In the literature there has been considerable interest over the years in how the distribution between work on the labour market and household work has developed and in how this distribution has been divided between women and men in the individual industrialised countries. In this connection several studies have shown that from the 1960s, 1970s and 1980s, populations have had less leisure time despite reductions in the negotiated annual working hours with a shorter working week and more holiday weeks. Two of the explanations have pointed to women's increasing participation in the labour market and an unchanged time use on unpaid household work.

This trend is also seen in Denmark, even though it is reduced by standardisation for the demographic distribution. The most robust result is a continued convergence in women and men's time use, which is to be found in all industrialised countries. As we have seen for paid work, this has been brought about by more equal employment rates among men and women and employed men’s reduced number of working hours. For unpaid work, the convergence is

mainly due to employed as well as non-employed men's increased contribution to that work. If, despite uncertainties, we make a linear projection of the trends in 18-74-years old women and men's time use, we have to go to the year 2033 before Danish women and men spend an equal amount of time in paid employment. For household work, gender equality will arrive as early as 2023.

We have also shown that the isolated effect of being a woman or being a man can explain an ever-decreasing part of the variation in household work over the last 45 years. From a relatively high explanation of the variation in 1964 the explanation falls markedly up to 1975 and again up to 1987, after which it becomes stable at this level. The most important reason why we can explain only an ever-smaller part of the variation is that gender means less than it has done for the differences in the amount of household work. In 1964 the difference in women and men's household work was 4 hours a day and in 2009 it was ¾ hour a day.

As could be expected, every time women took on paid work, they were relieved of some household work. However, this was only the case up to 1987, after there was no significant difference in how women and men's paid work affected the time spent on household work.

Our conclusion is that over the years a convergence has been taking place between women and men's time use, and that this development has been very marked in Denmark, as a country belonging to the Scandinavian welfare regime model.

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Human capital investments in children – A comparative analysis of the role of parent-child shared time in selected countries

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Abstract

In this paper, we test the hypothesis of parent-child time as a form of human capital investment in children using a propensity score treatment effects approach that accounts for the possible endogenous nature of time use and human capital investment. We broaden the human capital investment notion and focus on shared time in eating, housework, leisure, and TV/video time. Furthermore, we investigate the extent to which the levels and composition of parent-child time varies across three countries: Finland, Germany, and the United States (as social democratic, conservative and liberal welfare regime). Our results reveal some cross-national differences in human capital investment and they provide mixed support for the hypothesis that non-care related parent-child time is human capital enriching. But our results also provide similarities across countries, indicating that family core functions may be common irrespective of welfare regimes.

JEL-Codes: D13, J24, C01

Keywords: Parent-child time, treatment effects, propensity score matching, Finland, Germany, USA

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1 Introduction

There is no doubt that both genes and living conditions affect children's development. Living conditions is a sum of many aspects where the family represents an important factor, especially in the younger ages. Furthermore, the society frames the living conditions for families; by the way the public infrastructure interacts with and supports families (Haveman and Wolfe 1995; Bowles et al. 2005).

Children are different in many ways and parents have different strategies for raising their kids. In general, parental involvement is comprised of three elements; interaction, availability, and responsibility (Lamb et al. 1987). A young child needs plenty of interaction and constant parental availability while an older child needs less interaction and parental availability since peers tend to become more important as children grow up. Children's upbringing calls for a long-range involvement of responsible parents. Parental interaction and availability can be measured as time spent with children while responsibility is less amenable to measurement.

Parental involvement can be seen as one form of investment in children's human capital. While an extensive literature documents the out-of-pocket investments that parents make (e.g., Lino, 2012), much less is known about their time-related investments. The few studies that link parental time to children's human capital development focus on parent-child time spent in specific activities such as shared leisure (e.g., cultural events, sporting activities), educational activities (e.g., helping with homework), and/or eating time. These studies document the positive relationship between the time parents share with children in non-care activities and developmental benefits within a single country (Buchel and Duncan 1998; Zick et al. 2001; Dubas and Gerris 2002; Crosnoe and Trinitapoli 2008). The literature suggests that when parents engage children in such activities they undertake important human capital investment.

Other scholars have undertaken comparative time use studies with the goal of assessing how different welfare regimes affect parents' time use, particularly child care time (Sayer et al. 2004; Sayer and Gornick, 2011; Craig 2005). Sayer and her colleagues find support for the hypothesis that public family policies influence both the level and relative contributions of mothers and fathers to child care time. Craig also finds that being a parent affects the workload differently across different countries.

Others have also interpreted pure child care as a measure of human capital investment (Bryant and Zick 1996; Chalasani 2007; Guryan, Hurst, and Kerney 2008). Time spent in child care comprises still a relatively narrow aspect of human capital investment in children. Hence, we want to broaden the human capital investment notion. We argue that there are a range of activities – beyond child care – that play a prominent role in parental human capital investments in children. These activities include time spent together eating, doing housework, engaging in leisure activities, and TV-watching.

In this paper, we focus on parental human capital investment by utilizing shared time with children. Furthermore, we choose Finland, Germany, and the USA to represent different types of welfare state regimes building on the work of Esping-Andersen (1999). We recognize that national welfare state regimes may be a function of citizens' preferences for human capital investment. But, modeling such endogeneity is beyond the scope of our investigation. Rather, we view our comparisons across the three countries to be descriptive only. Our more important contribution in this paper is our use of propensity score modeling that allows for endogeneity in time use choices and human capital to examine a broader range of human capital enriching activities within the family.

The paper is organized as follows. In section 2, we provide arguments for parental time use as human capital investment in their children and why such investments may vary between countries. An overview of the method used and its justifications is presented in section 3. In section 4, we describe the data sets, and in section 5, we lay out the results which are followed by a summary in section 6.

2 Human capital investment – Shared time with children

Human capital is a broad concept; and the formation of human capital is the sum of many different things. Each child inherits an initial human capital endowment from her/his parents. However, of crucial importance to a child's development are the subsequent investments that are made in her/his human capital. Parents play an important role in the formation; they invest among other things time, money, and emotional energy in their children.[1] Time spent together with children can be considered a comprehensive measure of parental input in human capital investment in children. We focus on four activities; eating, doing housework, leisure, and TV-watching.

Time spent eating is thought to be enriching if it is done with family members in part because of the nutritional and eating habits it can convey and because it provides parents with an opportunity to engage their child(ren) in conversation. Family members relate events of the day, plan and coordinate future activities, discuss their accomplishments and frustrations, etc. When family members eat together, they typically also eat a more balanced and nutritious meal (Neumark-Sztainer et al. 2003; Eizenberg et al. 2004; Traveras et al. 2005; Spear 2006).

Housework may be a form of human capital investment if the child is well supervised. The parent can teach the child specific tasks, the child learns cooperative behavior, and it fosters re-

[1] See Klevmarken (1999) for a discussion of the broad variety of direct and indirect human capital investments in children.

sponsibility. At the same time, the child also learns gender-specific behaviors and gains an awareness of the family's socioeconomic status (see Goodnow 1988 for an overview).

Leisure activities can also be a form of human capital investment. Play can promote positive development, including cognitive, linguistic, social and emotional development. Structured activities like sports, arts, music, hobbies, and organizations offer high challenge, concentration, and motivation (Larson 2001).

TV or video watching is not typically associated with positive developmental experiences for children. Unsupervised and for long hours, it is associated with among other things obesity, lower school grades and aggressive behavior (Larson 2001). But, if a parent watches TV together with a young child it may be a more positive activity.

Not only parents, but also the public sector acts as investor. Becker and Tomes (1986) argue that if parental and public investments are perfect substitutes, parental investments will be crowded out as public investments expand. If parental and public investments are not perfect substitutes, public investments might still affect parental behaviors. Regardless, the idea that parental and public investments are important inputs in their children's human capital is beyond dispute. The most directly observable form of public investment in children is education. However, the public sector also invests considerable resources in children through the choices that the politicians make about subsidies for health care, work-related child care, and other forms of family policies.

We assume that all parents want to insure that their children acquire some optimal level of human capital. Yet, countries with different welfare regimes are different in the way family life, the labor market, and the public sectors are organized. These differences may alter the decisions that parents make about the time they spend with their children in potentially human capital enhancing activities. Alternatively, cultures with strong preferences for human capital investment may develop governmental supports for such investment. While we recognize the possibility of such endogeneity, such modeling is beyond the scope of our data. Thus, we elect to draw attention to cross-country differences descriptively in the hopes of motivating future research that would formally model how government policies interact with parental investments in children's human capital.

To gain insights from the descriptive comparisons, it is important to provide information regarding the countries' political context. Social democratic governments generally provide the greatest resource supports to families and children, followed by conservative governments, and lastly by liberal governments (Esping-Andersen 1999). If welfare states are viewed as a predetermined characteristic of the family environment that potentially substitutes for parental human capital investments (i.e., if there is no endogeneity), then we would expect that parents in social democratic countries would spend the least time investing in their children, followed by parents in conservative countries, with parents in liberal countries spending the most time investing in their children. If the structure of welfare states is influenced by parental preferences for children's human capital investment, then we would expect to observe parental investments

to be the highest in countries with social democratic governments, followed by countries with conservative governments and lastly by countries with liberal governments.

With data from only three countries and the complex welfare regime background we cannot rigorously test any hypotheses regarding the influence of welfare regimes. Nevertheless, recognition of the potential roles that welfare regimes play guides our work by suggesting that estimation should be done separately for each country because of the possibility that differences in government support interact with other independent variables to affect parent-child time. It also provides us with a lens to interpret any cross-national differences that we observe. Thus, our estimation will be country specific and our discussion will compare and contrast the country-specific results and suggest how future research might rigorously test the welfare regime hypothesis.

Parental investments in their children likely vary by age. At very young ages, parents typically spend considerable time caring for children. As children grow up, the need for parental supervision and interaction wanes. Given the importance of parental involvement at early ages, we choose to focus on parental time spent with children under the age of 10.

3 Modeling human capital investment – A treatment effects approach

Ideally, our analyses would make use of longitudinal data where parental time spent with a child during the early years is linked to human capital-related child outcomes at a later point in time (e.g. linking parental time spent with a child during the early years to a child's ultimate educational attainment using a panel econometric approach), or alternatively make use of a natural experiment. Unfortunately, there are no such data sets currently available.[2] Thus, we must fall back on the use of cross-sectional time diary data. The use of cross-sectional data to investigate questions of time use and human capital investment raises issues about the possibility of endogeneity of parental choices about how they spend their time and whether or not their time should be shared with a child.[3]

Concern about the potential dependence between time allocation and the decision to share certain types of time with children would disappear if eligible respondents were randomly assigned to have a child present during specific activities. But, they are not. Rather, respondents self-select as to how much time they spend in certain activities and that self-selection may be related to whether or not a child is present. One approach to this self-selection issue would be to

[2] While some longitudinal data sets (e.g., the Panel Study of Income Dynamics) contain time diary information on parent-child time along with child outcome data, the window of observation for parent-child time is typically short. This, in turn, limits the researcher's ability to draw conclusions regarding causality from the empirical modelling.

[3] By restricting our analyses to those couples who have one or more children under age 10 in the home, we control for the possible endogeneity of fertility.

estimate a simultaneous system. This strategy is limited by the functional form that is chosen and by the reality that such methods may hide the fact that many in the "treated" sample have no counterfactual in the non-treated sample (i.e., there is a lack of common support) (Black and Smith 2004; Gibson-Davis and Foster 2006).

Rosenbaum and Rubin (1983; 1984) propose the use of the propensity score method which approaches the simultaneity problem by balancing a treatment group (i.e., parents participating in an activity with one or more children under age 10 present during the activity; the treatment thus is the presence of those children) with a control group (i.e., parents participating in the same activity with no children under age 10 present) with regard to their covariates. Essentially, the propensity score adjusts for the bias that may be caused by certain types of parents self-selecting into doing certain activities when children are present by creating matches between members of the treatment and control groups rather than through the random assignment that is used in true experiments (Angrist and Pischke 2009).

The propensity score approach relies on first estimating a logit type equation where the dependent variable is the presence or absence of a child under age 10 during an activity spell $D = (1,0)$. The independent variables in the logit model, X, include factors that might affect whether or not the child is present as well as factors that might affect how much time is spent in the activity. The specification of the functional form and the independent variables can vary as the goal is simply to maximize the predictive capabilities of the model. However, we include content driven explanatory variables which in addition should minimize possible unobserved heterogeneity. From the logit estimates, the predicted probabilities of having a child present while participating in an activity are generated for all respondents. These predicted probabilities become the features on which treated parent-child spells are matched to control spells of parental time.

Next, a common support region is important and only those observations that fall within this region are further analyzed. The common support region is defined by the area of overlap in propensity scores for the treated and untreated groups. Within the common support area, members of the treatment group can be matched to members of the control group. A number of matching methods are used in the literature and these methods reflect the tradeoffs one must make between bias and variance when matching with small sample sizes (Gibson-Davis and Foster 2006; Caliendo and Kopeinig 2008). However, when sample sizes are large, the various matching approaches should produce similar results. Once the matching is complete, t-tests are conducted to ascertain if statistically significant differences exist between the treatment and the control groups with respect to spell length.[4]

[4] We also used a second method to compare the outcome of the treated and control groups, namely a linear regression specification with all of the observations in the common support area (Gibson-Davis and Foster, 2006). The dependent variable is the duration of the spell of the activity (Y). Independent variables in the regression are the respondent's propensity score (prob(X)) and a dummy variable indicating whether or not a child under the age of 10 was present during the activity: (D)

$$Y_i = \beta_0 + \beta_1 prob(X_i) + \beta_2 D_i + \varepsilon_i$$

In our application, if the length of the spell of each activity is dependent on the presence (absence) of a child after adjusting for the propensity score, this becomes a weak test of human capital investment. That is, such a result would be consistent with the hypothesis that parents will spend more time in an activity when a child is present because they are using some of that time to invest in the child's human capital (e.g., talking with the child while eating dinner, teaching a child how to cook while making dinner). It is a weak test because differences in spell length could also reflect differences in the current consumption value of engaging in an activity with or without a child. For example, meals may simply be more enjoyable for a parent when they are eaten with a child present and this leads the parent to devote more time to eating.

In using the propensity score approach, we are estimating the population average treatment effect on the treated (ATT). This is the causal effect of treatment only on that group and not the overall treatment effect. As mentioned, treatment (control) in this case is the presence (absence) of a child under age 10 during an activity spell, (D=(1,0), where 1=child present and 0=child not present). The outcome is the length of the spell in minutes $Y=(Y^1,Y^0)$. The causal effect of treatment is defined as $\Delta_{ATT}=Y^1-Y^0$. The mean of Δ_{ATT} is defined according to:

$$(1) \qquad \Delta_{ATT}=E(\Delta_{ATT}\mid D=1)=E(Y^1-Y^0\mid D=1)=E(Y^1\mid D=1)-E(Y^0\mid D=1).$$

However, as equation (1) is formulated, it cannot be estimated because we do not have both the treated and non-treated spell length for one person at the same time on the individual level. Hence the last term can be analyzed only based on averages.

To make the estimation tractable, and to meet the causal effects of a treatment by the propensity score method, three conditions must hold. First, once we control for observable covariates, X the potential outcome is independent of the treatment selection. This is known as the conditional independence assumption (CIA). This assumption allows the means of Δ_{ATT} to be estimated by using the observable untreated $E(Y^0\mid D=0,X=x)$ instead of the not observable untreated $E(Y^0\mid D=1,X=x)$ in equation (1). The conditional independence assumption (CIA) can be formalized according to:

$$(2) \qquad Y^0 \perp D\mid X\ .$$

In our case, this means that the presence of a child should be random after we control for X. We meet the CIA assumption by doing two things. First, we include in X both parental and child characteristics that have been found to be associated with time spent with children (Buchel and Duncan 1998; Zick et al. 2001; Dubas and Gerris 2002; Sayer et al. 2004; Craig 2005; Crosnoe and Trinitapoli 2008). We follow the specification of past research as closely as possible across all three analyses given the limits on the information available in each of the

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If the coefficient associated with the dummy variable (β_2) is statistically significant, then this is an indication that there are treatment effect differences. These results are close to the matching results, and to save space not shown here. However, the results are available upon request.

three time diary data sets we utilize.[5] Second, we focus on parental time-use activities that are done whether or not a child is present (i.e., eating, housework, leisure, watching television). It is arguable that often a child may be off playing with friends, at day care, at school or engaged in other activities away from the parent. This allows for the possibility that the child's presence during a specific activity may be somewhat random. To the extent that spells with children may be a function of structural factors, we include among our covariates measures of structural aspects of the spell characteristics including time of day, day of week, and season of the year. We assess whether or not these actions help us meet the CIA requirement by conducting t-tests to assess if the distributions of the X's are the same between the treated and untreated groups (Caliendo and Kopeinig 2008).

The second condition that must be met is the common support assumption. That is, the estimated probabilities of participation for the treatment group must overlap with the estimated probabilities of participation for the control group and the probabilities have to be positive, irrespective of the value of X (Imbens 2004; Smith and Todd 2005; Caliendo and Kopeinig 2008). To meet this condition, we drop treatment observations whose propensity score is higher than the maximum or less than the minimum of the controls. Once the common support region criterion has been satisfied, we use nearest neighbor matching with replacement to pair spells in the treated group (i.e., child present for the specified activity) with spells in the non-treated group (i.e., child not present for the specified activity). Our sample sizes are relatively large and thus nearest neighbor matching with replacement should produce unbiased results that are quite similar to other matching methods although the variance may be increased (Caliendo and Kopeinig 2008).[6] As such, this matching technique provides a conservative test.

The final condition that must be met in order to estimate the ATT is the stable unit treatment value assumption (SUTVA). SUTVA requires that the outcome of a unit depends on the own participation only and not on the treatment of the other units. Satisfying SUTVA would be a problem if we pooled mothers and fathers from the same family in our analyses. To avoid violating this assumption, we estimate propensity scores separately for mothers and fathers. This approach also insures perfect matching on gender (Heckman, Ichimura, Smith, and Todd 1998).

4 Data sets

We construct compatible time diary data sets for Finland, Germany, and the United States given the limitations that are inherent in each data set's design. Specifically, we restrict our samples to respondents with complete time diaries, who are between the ages of 20 to 60, who are married or cohabiting, and who have one or more minor children under the age 10 present in the home. We choose these three countries because they represent three different types of family

5 Some descriptive measures for the covariates included in X for the three countries are shown in Appendix.
6 Matching is done using the STATA psmatch2 procedure (Leuven and Sianesi, 2003).

policies that vary by welfare regimes. Again, Finland's family policies are consistent with the social democratic welfare approach, while Germany's policies reflect the conservative welfare approach and policies in the United States reflect a liberal welfare approach.

The *Finnish Time Use Survey* (FTUS) was conducted in 1999-2000 by Statistics Finland. The FTUS design follows EUROSTAT's Guidelines on Harmonised European Time Use Surveys (HETUS). The survey is a representative sample covering persons aged 10 and above. The data included 5,300 individuals from 2,600 households. Participants were asked a series of questions regarding their personal characteristics and one household member was asked about the household characteristics. Some information regarding their income was added to the survey from tax registers. All respondents were asked to fill in a time use diary based on 10-minute intervals for two days, one weekday and one weekend. For each 10-minute spell, respondents filled in their primary activity and what else they were doing at the same time. They were also asked to fill in with whom they spent their time, the location and mode of transportation. For this data set, the information on with whom respondents spent their time was not available for those respondents interviewed in January and February. Hence, observations from those two months are missing (Niemi and Pääkkönen 2001). Our present sample consists of 329 fathers and 363 mothers, observed for two days.

The *German Time Use Survey* (GTUS) of 2001/02 provided by the German Federal Statistical Office consists of about 5,400 households and approximately 37,700 diary days. The GTUS design also follows EUROSTAT's Guidelines on Harmonised European Time Use Surveys (HETUS). All household members aged 10 years and older were asked to fill out diaries based on 10-minute intervals on three days – two days during the week from Monday to Friday, one day on the weekend. Data were collected on primary and secondary activities, persons involved or present (children below 10 years old, partner, other household member, known other persons) for each single activity. Household and individual data (i.e., socio-demographic/economic variables and other background variables) were collected in additional questionnaires. A comprehensive *GTUS-Compass* about the broad range of GTUS 2001/02 information and its usage is provided by the German Federal Statistical Office (Ehling, Holz and Kahle 2001; Statistisches Bundesamt 2006). There are 890 fathers and 890 mothers, observed for three days, in the sample used for the current analysis.

The third time diary data set is the 2003 *American Time Use Survey* (ATUS). The 2003 ATUS is the first annual American time-diary survey conducted by the U.S. Bureau of Labor Statistics and thus the closest ATUS survey to the Finnish and German data. Each year a sample is drawn from those households that have completed the final interview for the Current Population Survey. The ATUS respondent is randomly selected from among each household's members who are age 15 or older. Respondents are asked a series of questions that focus on household composition, employment status, etc. They are also asked to complete one 24-hour time diary using retrospective recording methods. Half of the respondents complete a diary for a weekday and half of the respondents complete a diary for a weekend day. For each activity the respondent

reports doing over the 24 hours, s/he is also asked who else was present when doing the activity. For the current analyses our sample consists of 2,416 mothers and 2,136 fathers, who had no missing data on the "who with" question.

Both the FTUS and GTUS are part of the Harmonized European Time Use Survey, where activities are comparable by design. We use the ATUS survey coding lexicons to create comparable activity categories with the FTUS and GTUS. Although the FTUS and GTUS data sets contain information on both parents' time use, we have data on only one parent in the ATUS. Thus, we elect to analyze mothers and fathers separately so as to be consistent. However, we recognize we lose information on the Finnish and German parents by doing this. It should also be noted that although the three surveys were conducted in different years, their close proximity in time makes the possibility of observing period-specific differences small.

In all the time use surveys, one diary day consists of information on activities during a 24 hour period. We do not use all information on the performed activities; the activities of interest in our analyses are spells of eating, housework (where child care is not included), leisure (where television and video viewing is not included), and television and video viewing. These activities may be considered child care in the broadest sense (Klevmarken 1999) but they are not seen as traditional child care when coding the parent's time. Thus, for each type of activity we examine whether or not a child was present during a spell and how long the spell lasted.

Individuals in the surveys can have multiple spells of each activity during the 24-hour diary period and in two of the three surveys, each individual has more than one 24-hour diary. Thus, all analyses correct for the correlation of error terms caused by having multiple spells from the same individual included in the analyses. In addition, all descriptive information is weighted using the weights provided in each data set. The multivariate analyses are not weighted as these analyses control for those factors used to construct the sampling weights (DuMouchel and Duncan 1983).

5 Results – Human capital investments in children

We focus on primary time in eating, housework leisure, and TV time because we believe they are the most common non-care related activities that offer the potential for parents to engage in child-related human capital investment. As mentioned, life skills may be taught by a parent while doing housework with a child or engaging in active leisure (e.g., playing a sport) with a child. Likewise, parents may talk to a child about his/her day or about current events, etc. over a meal, or even while engaging in leisure activities. Admittedly, it is less likely that human capital investment occurs when a parent watches television or a video with a child. But, even television/video viewing may provide a parent with some "teachable moments".

In Table 1, mean daily times spent in the selected activities are presented for the samples in order to give some background to our analyses.

On average, German parents spend the most time in eating while the parents in the United States spend the least time in eating. Mothers clearly spend more time in housework than fathers in all three countries, and German parents are the most diligent in devoting time to housework. Parents in the United States spend the least time in housework, and Finnish parents are in between. Parents in the United States spend less than two hours per day on average in leisure activities, while parents in Finland and Germany spend around two and a half hours per day. At the same time, parents in the United States generally spend somewhat more time watching TV than their counterparts in Finland and Germany. Though the overall picture across the three countries is heterogeneous, differences with regard to the amount of activity time can be recorded.[7]

Table 1
Weighted mean daily duration (in minutes) in selected activities in Finland, Germany and the United States

	Finland		Germany		United States	
Activity	Fathers	Mothers	Fathers	Mothers	Fathers	Mothers
Eating	78	78	96	106	58	59
Eating with children < 10	36	50	61	78	39	46
Housework	114	218	161	283	93	179
Housework with children < 10	40	112	36	96	28	76
Leisure	152	145	165	166	99	95
Leisure with children < 10	55	71	54	68	48	54
TV	110	92	104	82	123	104
TV with children < 10	38	45	15	15	54	55
N diary days	623	695	2666	2668	2256	2583
N observations	329	363	890	890	2256	2583

Source: FTUS 1999-2000. GTUS 2001/02, ATUS 2003, own calculation.

When it comes to shared time, German parents also spend the most time eating with children under 10 years old on average, while they share relatively smaller amounts of TV viewing time. Parents in the United States, share more TV watching and generally share less eating and less housework time than their counterparts in Finland and German. Finnish parents on the other

[7] All mentioned differences are statistically significant, except that the fathers in the United States watch more TV than the fathers in Finland but the difference is not statistically significant. The t-tests are available upon request.

hand, share housework for longer periods with children under 10 years old on average than other parents but their shared time spent eating with children is shorter.[8]

Times spent in the four selected activities are not spent consecutively; rather they are spent in several spells over the course of the day. Table 2 shows the mean times for spells in the four different activities by whether or not a child less than age 10 was present.

Table 2 also provides an opportunity to compare and contrast the estimates across the three countries. Focus on the rows that report spells spent with one or more children under age 10. These rows reveal that shared parent-child spells for eating, housework, leisure, and TV viewing are all longest for mothers and fathers in the United States, and the differences are statistically significant. German parents' average spell length for eating and leisure time is in the middle and Finnish parents' average spell lengths are the shortest. Spell length for housework and TV watching are not statistically different between Finnish and German parents.[9] However, if parental time spent in these four activities involves some human capital investment on the part of their children, then these differences hint that government policies may be associated with cross-national differences in parental human capital investment.

Comparing the spells with children present to the spells without children present reported in Table 2, we observe that spell length for the four activities in question is generally shorter for Finnish mothers and fathers when one or more children under age 10 is present compared to when no children are present, the only non significant difference is eating time. In contrast, in Germany, the eating and leisure spells for mothers and fathers are longer when children are present relative to when they are not present, and the opposite holds for housework and TV watching. Finally, in the United States, the spells are relatively longer when one or more children under age 10 are present, with the exception of housework for fathers where the difference is not significantly different.[10] This pattern across countries is again consistent with the argument that government supports may substitute for some parental human capital investments in social democrat countries like Finland.

To more confidently assess whether or not shared parent-child time in non-care activities involves human capital investment, we must move beyond the bivariate comparisons in Table 2 for two reasons. First, the observed bivariate relationships could be spurious if family socio-demographic characteristics also play a role in parent-child shared time. Second, parents may self-select into shared versus non-shared time use spells. To address these two potential shortcomings, we contrast the above findings with the results obtained using a treatment effects approach by propensity score methods where similar parents are matched and their time use is compared.

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8 All mentioned differences are statistically significant, except the difference between fathers' housework time in Finland and Germany are not statistically significant. Furthermore, fathers in Finland and the United States spend equally long amount of time eating with their children. The t-tests are available upon request.

9 The t-tests are available upon request.

10 The t-tests are available upon request.

Table 2
Weighted mean times for spells spent in various activities by presence/absence of one or more children under age 10

	Finland						Germany						United States					
	Fathers			Mothers			Fathers			Mothers			Fathers			Mothers		
	Mean	N Spells	N Resp.[a]	Mean	N Spells	N Resp.[a]	Mean	N Spells	N Resp.	Mean	N Spells	N Resp.[a]	Mean	N Spells	N Resp.[a]	Mean	N Spells	N Resp.[a]
All Spells																		
Eating	22.85	2173	326	21.13	2574	363	31.32	8203	890	30.53	9333	890	32.98	3787	2000	33.41	4557	2355
Housework	31.63	2364	310	29.58	5105	363	31.15	13721	888	31.94	23791	890	49.50	3898	1521	38.00	10950	2374
Leisure	45.26	2200	320	37.00	2819	361	50.95	8665	887	44.81	10010	888	69.11	3071	1519	61.65	4010	1833
TV	53.32	1393	302	43.44	1474	334	73.93	3748	823	64.04	3335	807	98.88	2914	1702	77.86	3365	1885
Spells with Children < 10																		
Eating	23.70	1037	280	21.33	1677	340	33.77	4838	870	31.71	6611	882	35.89	2497	1613	34.39	3581	2100
Housework	28.69	923	233	28.02	2777	341	29.06	3211	737	29.12	8322	867	50.31	1237	752	40.09	4493	1780
Leisure	42.10	911	253	34.55	1501	323	56.16	2595	760	47.64	3603	816	84.93	1418	905	73.05	2099	1259
TV	44.12	602	217	39.22	793	272	42.98	910	467	42.54	903	450	104.24	1303	955	82.26	1728	1176
Spells without Children < 10																		
Eating	22.15	1136	304	20.77	897	297	27.86	3365	835	27.71	2722	767	28.68	1290	963	30.41	976	771
Housework	33.49	1441	290	31.44	2328	338	31.82	10510	886	33.62	15469	890	49.17	2661	1264	36.55	6457	1985
Leisure	47.30	1289	298	39.74	1318	316	49.14	6070	879	43.02	6407	872	58.18	1653	1006	50.62	1911	1167
TV	59.84	791	274	48.43	681	273	83.91	2838	807	72.29	2432	783	94.88	1611	1164	73.21	1637	1215

[a] Respondents

Source: FTUS 1999-2000. GTUS 2001/02, ATUS 2003, own calculation.

In Table 3, the results for a nearest neighbor matching propensity scores are presented.[11] With regard to the matching quality, the common support assumption is met as there is a broad overlapping score region for all activities in each country.[12] There are generally more treated relative to the untreated respondents when the probability of time shared with a child is higher which is in some favor of our maintained hypothesis. We also test the resemblance of the covariates in the treated and control groups in all activities. After matching, the respective means of the covariates for each country are very close which empirically supports the CIA. The significant bias reduction of the matched covariates and the valid null hypotheses of no differences of the matched covariate means of the treated and the control group supports the argument of a successful matching procedure with important and central explanatory variables by the selection on observables in the logit estimates behind.[13]

Turning to the propensity score results presented in Table 3, focus first on **eating** time. As our results in Table 3 suggest, fathers in all three countries spend significantly more time in eating spells if a child less than 10 years old is present. The largest increases in shared eating time are for fathers in the U.S. followed by German fathers and then by fathers in Finland. The results for mothers are more mixed with only German mothers spending significantly more time. The rank ordering for the fathers are consistent with the notion that government policies may also play a role.

Considering **housework**, Table 3 reveals that Finnish and German mothers and fathers, along with American fathers, all spend less time in housework if one or more children under age 10 are present (although the estimates for Finnish mothers, German fathers, and American fathers do not reach conventional levels of statistical significance). Only American mothers spend more time in housework spells when a young child is present, suggesting that they may view such time to be human capital enriching.

It is important to note that we cannot tell from these data whether or not the children are helping with the chores. We only know that they are present. Thus, a number of stories are consistent with our findings. It may be that children in Finland and Germany are more helpful in doing the chores (allowing their parents to finish more quickly), while the presence of children in the United States dampen their mothers' housework productivity. Alternatively, it may be that mothers in the United States are simultaneously teaching their children how to do the tasks which may decrease their productivity in the short run but enhance their children's human capital in the long run. In any case, the marginal differences in spell length are small. More confident conclusions regarding these cross-country differences can only be ascertained with data

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11 The means for the covariates are presented in the Appendix Tables 5-6. Marginal effects for the logistic regressions are available upon request.

12 The common support graphs are available upon request.

13 The results of the t-tests for the differences in the covariates before and after matching are presented in the Appendix Tables 5-6 showing that there are no differences of the matched logit covariate means of the treated and the control group.

(either qualitative or quantitative) that examines not only the time inputs but also the household production outputs.

The coefficients for **leisure** time are negative for Finnish parents, however only statistically significant for mothers (-7 minutes). On the other hand, both German and American mothers and fathers spend significantly more time in leisure activities if one or more children under age 10 are present. The sizes of the estimated time differences are larger for the American parents. Again, the differences we observe across the three countries suggest that government policies may play a role in the decisions parents make about children's human capital investment as reflected by shared parent-child time.

Table 3
Average treatment effect on the treated (ATT) – Difference in time use (in minutes) by presence/absence of a child under age 10 using nearest neighbor matching (standard error in parentheses)[a]

		Finland		Germany		United States	
		Difference	N[b]	Difference	N[b]	Difference	N[b]
Fathers	Eating	2.70	2158	4.17	8202	5.18	3781
		(1.07) **		(0.91) ***		(1.65) ***	
	Housework	-8.85	2362	-1.82	13721	-4.93	3896
		(-3.45) ***		(1.22)		(4.05)	
	Leisure (no TV)	-1.56	2198	5.34	8662	20.56	3071
		(3.84)		(2.38) **		(4.09) ***	
	Television	-10.54	1389	-38.82	3694	11.29	2903
		(3.15) ***		(3.34) ***		(5.05) **	
Mothers	Eating	0.82	2558	2.10	9332	0.40	4534
		(1.14)		(0.94) **		(1.82)	
	Housework	-0.69	5105	-3.37	23791	2.54	10949
		(1.86)		(0.99) ***		(1.45) *	
	Leisure (no TV)	-6.79	2817	7.30	10008	18.18	4006
		(2.82) **		(1.73) ***		(3.63) ***	
	Television	-7.40	1473	-25.41	3317	4.62	3362
		(2.58) ***		(2.64) ***		(4.62)	

***p<.01 **p<.05 *p<.10

[a]Standard errors are obtained using bootstrapping methods, where the estimates are replicated 100 times and correct for the clustering of multiple observations from the same individual.

[b]The reported sample size for each analysis is based on the number of person-spells within the common support region. The actual degrees of freedom in each analysis are much smaller as the t-tests correct for the clustering of multiple observations from the same individual.

Source: FTUS 1999-2000. GTUS 2001/02, ATUS 2003, unweighted, own calculation.

The results for **TV-watching**, show that both Finnish and German parents spend significantly less time watching TV if a child less than 10 years old is present, and the magnitude of these differences is fairly large (Finns 7-11 minutes and Germans 25-39 minutes less time). In con-

trast, parents in the United States watch 5-11 minutes more TV if a child is present (although the estimate for mothers not significant). The negative estimates associated with shared television viewing time in Finland and Germany are consistent with the general view that television/video viewing does not promote positive developmental outcomes. In the case of the American parents, the positive difference might be interpreted as a human capital investment if the program they watch with their children is educational or generates parent-child discussion. But, more likely, the change in signs simply reflects American adults' greater relative preference for television viewing over other leisure activities.

6 Summary and conclusions

In this study we assess if non-care related parent-child time has an element of human capital investment associated with it by utilizing data from three different countries. We analyse non-care related human capital investment time by focusing on the time parents share with their children in four potentially enriching time use categories: eating, housework, leisure (excluding TV), and television/video viewing. In the multivariate analyses we control for other possible confounding socio-demographic factors and we adjust for possible endogeneity using propensity score treatment effect techniques. We compare the impacts on time spent in selected activities for treatment (child present) and non-treatment groups (child not present) by nearest neighbor matching. In both the descriptive and the multivariate analyses, we find evidence of human capital investment as it relates to parent-child shared time.

Our results provide mixed support for the hypothesis that non-care related parent-child time is human capital enriching. The strongest support is found in the case of leisure time (both parents in Germany and the U.S.) and eating time (fathers only in all three countries). For these two categories we see that the presence of children is typically associated with longer spells and this result is consistent with the human capital investment hypothesis. Our results for housework and television/video viewing time provide no support for the human capital enrichment argument. In the case of television/video viewing time, the result is not surprising. The absence of support for shared housework as human capital enriching may reflect the more general trend away from investing in domestic skills. In recent years, advances in household technology and the growing availability of paid housekeepers have increasingly substituted for family members' housework time in many countries thus reducing the need for individual family members to possess high levels of household production related human capital. Furthermore, the children in this study are under 10 years old, and their young ages may sometimes lead them to be excluded from housework responsibilities.

Do parents and governments serve as substitutes with respect to children's human capital investment? The current analyses cannot provide a definitive answer. We find some differences, but also similarities across the three countries. Similarities across countries indicate that family core functions are common irrespective of different welfare regimes. But, future research needs

to disentangle the direction of causality with respect to welfare regime effects. Finally, we interpret the positive differences in shared eating and leisure activities to be an indication of parental investment in children's human capital. Another interpretation of these findings would be that parents simply place a higher value on the consumption aspects of shared time spent eating and engaging in leisure. Clearly, a more definitive test of parental investment in children's human capital would involve linking such time to specific child outcome measures. As with assessing the impact of various family policies, more definitive tests await new data sets that contain detailed information on parental inputs, societal inputs, *and* child outcomes.

Appendix

Table 4
Means for covariates

	Finland		Germany		United States	
Variables	Fathers	Mothers	Fathers	Mothers	Fathers	Mothers
Age	36.76	34.6	39.14	36.43	38.07	35.94
Proportion female children in the home	n.a.	n.a.	n.a.	n.a.	0.49	0.5
Number of children ≤ age 5 (US) ≤ 6 (FI)	1.09	1.08	n.a.	n.a.	0.91	0.89
Number of children age 6-17 (US) 7-17 (FI)	0.98	1.03	n.a.	n.a.	1.23	1.24
Number of children in household age 0-17	---	---	2.11	2.11	---	---
Employed (1=yes)	0.9	0.64	0.94	0.64	0.91	0.60
Weekend diary (1=yes)	0.5	0.5	0.35	0.35	0.53	0.49
Fall diary (1=yes)	0.31	0.32	0.25	0.25	0.24	0.24
Spring diary (1=yes)	0.33	0.32	0.29	0.29	0.25	0.25
Winter diary (1=yes)	0.07	0.08	0.23	0.23	0.25	0.25
Years of schooling	---	---	---	---	14.56	14.45
Elementary schooling (9 years) (1=yes)	---	---	0.25	0.13	---	---
Intermediate schooling (10 years (DE) 12 (FI)) (1=yes)	0.46	0.46	0.3	0.44	---	---
Supper schooling (13 years) (1=yes)	---	---	0.44	0.42	---	---
University diploma (DE) University degree (FI) (1=yes)	0.34	0.39	0.19	0.11	---	---
Hispanic (1=yes)	---	---	---	---	0.13	0.14
Asian (1=yes)	---	---	---	---	0.04	0.03
Black (1=yes)	---	---	---	---	0.06	0.04
Other race/Ethnicity (1=yes)	---	---	---	---	0.01	0.01
German (1=yes)	---	---	0.98	0.98	---	---
East Germany (1=yes)	---	---	0.12	0.12	---	---
Cohabiting (1=yes)	---	---	---	---	0.05	0.05
Married (1=yes)	0.78	0.78	0.95	0.95	---	---
Spell occurred 12am-6am (1=yes)	0.03	0.02	0.04	0.01	0.04	0.02
Spell occurred 6am-12pm (1=yes)	0.25	0.27	0.28	0.31	0.28	0.29
Spell occurred 12pm-6pm (1=yes)	0.37	0.38	0.32	0.37	0.37	0.4
Number of respondents	329	363	890	890	2256	2583
Total number of spells	10070	14045	42869	56396	22805	34998

NOTE: Omitted category for schooling in Finland is Compulsory Schooling, in Germany No Schooling. Omitted category for race/ethnicity is White/Non-Hispanic in the United States. Omitted category for spell time is 6pm-12am, and omitted category for season is diary was in spring in all countries.

Source: FTUS 1999-2000. GTUS 2001/02, ATUS 2003, not weighted data, own calculation.

Table 5
Matching results: P-values of T-tests for the differences in the covariates after matching; mothers in Finland, Germany, USA

Independent variables	Eating			Housework			Leisure			Television		
	Finland	Germany	USA	Finland	Germany	USA	Finland	Germany	USA	Finland	Germany	USA
Age	0.499	0.663	0.979	0.945	0.789	0.330	0.581	0.500	0.838	0.315	0.653	0.774
Age squared	0.405	0.795	-	0.892	0.809	-	0.505	0.467	-	0.350	0.608	-
Number of children age 0-17	-	0.937	-	-	0.540	-	-	0.904	-	-	0.269	-
Proportion female children in the home	-	-	0.392	-	-	0.369	-	-	0.056	-	-	0.902
Number of children age 0-6	0.149	-	-	0.958	-	-	0.663	-	-	0.097	-	-
Number of children age 7-17	0.476	-	-	0.708	-	-	0.798	-	-	0.043	-	-
Number of children < age 6	-	-	0.033	-	-	0.484	-	-	0.438	-	-	0.550
Number of children age 7-17	-	-	0.339	-	-	0.118	-	-	0.523	-	-	0.489
Employed	0.101	0.022	0.414	0.466	0.119	0.421	0.020	0.774	0.950	0.920	0.086	0.946
Weekend diary	0.702	0.306	0.374	0.707	0.753	0.321	0.883	0.062	0.949	0.616	0.634	0.411
Fall diary	0.010	0.305	0.889	0.040	0.757	0.013	0.008	0.589	0.021	0.625	0.419	0.248
Spring diary	0.547	0.089	0.805	0.749	0.391	0.349	0.085	0.756	0.465	0.027	0.414	0.385
Winter diary	0.394	0.279	0.451	0.768	0.185	0.016	0.487	0.140	0.347	0.001	0.755	0.173
Years of schooling	-	-	0.215	-	-	0.993	-	-	0.068	-	-	0.708
Elementary schooling (9 years)	-	0.479	-	-	0.479	-	-	0.883	-	-	0.646	-
Intermediate schooling (10 years (DE) 12 (FI))	0.444	0.958	-	0.830	0.742	-	0.535	0.635	-	0.840	0.571	-
Supper schooling (13 years)	0.181	0.370	-	0.532	0.827	-	0.941	0.585	-	0.324	0.467	-
University diploma (DE) / degree (FI)	-	0.146	-	-	0.828	-	-	0.473	-	-	0.636	-

Table 5 Cont.
Matching results: P-values of T-tests for the differences in the covariates after matching; mothers in Finland, Germany, USA

Independent variables	Eating			Housework			Leisure			Television		
	Finland	Germany	USA	Finland	Germany	USA	Finland	Germany	USA	Finland	Germany	USA
Hispanic	-	-	0.429	-	-	0.663	-	-	0.351	-	-	0.138
Asian	-	-	0.668	-	-	0.687	-	-	0.007	-	-	0.569
Black	-	-	1.000	-	-	0.005	-	-	0.528	-	-	0.324
Other Race/Ethnicity	-	-	0.734	-	-	0.026	-	-	0.036	-	-	0.653
Cohabitating	-	-	0.578	-	-	0.497	-	-	0.400	-	-	0.418
Spell Occurred 12am-6am	1.000	1.000	0.818	0.796	1.000	1.000	0.722	1.000	0.827	1.000	-	0.808
Spell Occurred 6am-12pm	0.136	0.175	0.000	0.931	0.415	0.006	0.036	0.011	0.029	0.023	0.928	0.572
Spell Occurred 12pm-6pm	0.832	0.229	0.016	0.311	0.394	0.225	0.606	0.321	0.599	0.750	0.911	0.510
Married	0.105	0.004	-	0.188	0.051	-	0.031	0.957	-	0.674	0.918	-
German	-	0.014	-	-	0.956	-	-	0.009	-	-	0.070	-
East Germany	-	0.097	-	-	0.287	-	-	0.044	-	-	0.565	-

Ho: no differences of the matched logit covariate means of the treated and the control group.
Source: FTUS 1999-2000. GTUS 2001/02, ATUS 2003, not weighted data, own calculation.

Table 6
Matching results: P-values of T-tests for the differences in the covariates after matching; fathers in Finland, Germany, USA

Independent Variables	Eating			Housework			Leisure			Television		
	Finland	Germany	USA	Finland	Germany	USA	Finland	Germany	USA	Finland	Germany	USA
Age	0.798	0.192	0.969	0.086	0.969	0.896	0.494	0.566	0.992	0.513	0.555	0.582
Age squared	0.827	0.274	-	0.138	0.982	-	0.461	0.485	-	0.614	0.572	-
Number of children age 0-17	-	0.716	-	-	0.920	-	-	0.611	-	-	0.892	-
Proportion female children in the home	-	-	0.918	-	-	0.049	-	-	0.659	-	-	0.824
Number of children age 0-6	0.817	-	-	0.206	-	-	0.522	-	-	0.490	-	-
Number of children age 7-17	0.717	-	-	0.833	-	-	0.580	-	-	0.662	-	-
Number of Children < age 6	-	-	0.005	-	-	0.643	-	-	0.894	-	-	0.825
Number of children age 7-17	-	-	0.151	-	-	0.986	-	-	0.505	-	-	0.577
Employed	0.533	0.030	0.767	0.093	0.526	0.838	0.222	0.878	0.207	0.621	1.000	0.427
Weekend diary	0.195	0.555	0.053	0.962	0.500	0.386	0.467	0.636	0.290	0.766	0.925	0.105
Fall diary	0.962	0.109	0.645	0.758	0.433	1.000	0.518	0.602	0.301	0.853	0.403	0.403
Spring diary	0.117	0.789	0.766	0.439	0.829	0.240	0.378	0.645	0.050	0.802	0.324	0.344
Winter diary	0.683	0.275	0.081	0.424	0.294	0.708	0.933	0.332	0.186	0.357	0.520	0.005
Years of schooling	-	-	0.345	-	-	0.727	-	-	0.004	-	-	0.974
Elementary schooling (9 years)	-	0.320	-	-	0.906	-	-	0.741	-	-	0.686	-
Intermediate schooling (10 years (DE) 12 (FI))	0.505	0.806	-	0.632	0.658	-	0.739	0.759	-	0.907	0.917	-
Supper schooling (13 years)	0.715	0.415	-	0.575	0.881	-	0.236	0.676	-	0.542	0.495	-
University diploma (DE) / degree (FI)	-	0.225	-	-	0.502	-	-	0.678	-	-	0.567	-

Table 6 Cont.
Matching results: P-values of T-tests for the differences in the covariates after matching; fathers in Finland, Germany, USA

Independent Variables	Eating			Housework			Leisure			Television		
	Finland	Germany	USA	Finland	Germany	USA	Finland	Germany	USA	Finland	Germany	USA
Hispanic	-	-	0.215	-	-	0.947	-	-	0.377	-	-	0.765
Asian	-	-	0.240	-	-	0.496	-	-	0.668	-	-	1.000
Black	-	-	0.017	-	-	0.717	-	-	0.854	-	-	0.699
Other race/ethnicity	-	-	0.886	-	-	0.547	-	-	0.237	-	-	0.694
Cohabitating	-	-	0.763	-	-	0.918	-	-	0.389	-	-	0.654
Spell occurred 12am-6am	1.000	1.000	0.834	0.705	1.000	0.713	0.561	1.000	1.000	1.000	-	1.000
Spell occurred 6am-12pm	0.091	0.209	0.532	0.753	0.938	0.801	0.305	0.085	0.719	0.145	0.179	0.959
Spell occurred 12pm-6pm	0.349	0.736	0.593	0.260	0.876	0.186	0.886	0.359	0.139	0.049	0.457	0.661
Married	1.000	0.928	-	0.910	0.951	-	0.148	0.743	-	0.744	0.844	-
German	-	0.305	-	-	0.553	-	-	0.619	-	-	0.189	-
East Germany	-	0.231	-	-	0.736	-	-	0.089	-	-	0.733	-

Ho: no differences of the matched logit covariate means of the treated and the co control group.
Source: FTUS 1999-2000. GTUS 2001/02, ATUS 2003, not weighted data, own calculation.

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New developments in time technology – projects, data, computing and services

CHAD EXPLORER – AN ENHANCED WEB APPLICATION FOR CHAD

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In 1999 the US Environmental Protection Agency (EPA) developed a Consolidated Human Activity Database (CHAD). CHAD has been used for various exposure modeling studies (McCurdy et al., 2000, Graham & McCurdy, 2004; McCurdy & Graham, 2003). Recently, CHAD has been improved and enhanced with a new web application called CHAD Explorer (CHAD-Ex).

CHAD Explorer (CHAD-Ex) consists of 24 h diaries for almost 35,000 U.S. citizens. These diaries are associated with location and activity codes (Robinson et al., 1989, (McCurdy & Graham, 2003). The studies included in CHAD-Ex are listed in Table 1. The diaries come from national and state-level random probability studies. The data were acquired between 1983 and 2008. About half of information is cross-sectional in nature, having one diary day of time use information per person, while the other half has between 2-369 days of data per person. CHAD and CHAD-Ex both can be found at the same web site (www.epa.gov/chadnet1)

Specifics about CHAD Explorer (CHAD-Ex)

CHAD-Ex takes advantage of the Oracle Application Express™ (OAE) as an integrated development environment for developing a database-driven web application which provides various ways for browsing and querying the sequential 24-h U.S. time use data contained in CHAD.

Table 1
Summary of the CHAD database

Study name	Year (last if multi-years)	Person-days of diaries	Number of days of data per person: Range of diary days	Number of days of data per person: Median	Sponsor
Denver MSA	1983	805	1	1	EPA
Washington DC MSA	1983	699	1	1	EPA
Cincinnati MSA	1986	2,614	1-3	3	EPRI
California - adolescents	1988	183	1	1	CARB
California - adults	1988	1,579	1	1	CARB
Los Angeles - elementary	1989	51	3	3	API
Los Angeles - high school	1990	43	2-3	3	API
California - children	1990	1,200	1	1	CARB
Valdez AK	1991	397	1	1	Oil companies
NHAPS - A	1994	4,723	1	1	EPA
NHAPS - B	1994	4,663	1	1	EPA
PSID (CDS) 1	1997	5,616	1-2	2	NICHHD
Baltimore elderly	1998	391	1-24	14	EPA
EPA #1*	2000	367	367	367	EPA
RTP Unhealthy	2001	1,000	8-33	32	EPA
Seattle MSA*	2002	1,693	5-10	10	EPA
EPA #2*	2002	197	197	197	EPA
PSID (CDS) 2	2003	4,782	1-2	2	NICHHD
RTI Averting behavior*	2003	2,907	1-6	4	EPA
Internal EPA*	2007	432	35-69	54	EPA
EPA #1*	2007	369	369	369	EPA
Mother & child*	2008	62	31	31	EPA
PSID (CDS) 3					
Totals		34,773			

Notes and abbreviations: *Added to CHAD via CHAD Explorer; # Number (of days); API = American Petroleum Institute; CARB = California Air Resources Board; CDS = Child Development Supplement; EPA = Environmental Protection Agency; MSA = Metropolitan Statistical Area; NHAPS = National Human Activity Pattern Survey (A=air version; B=water version); NICHHHD = National Institute of Child Health and Human Development; PSID = Population Study of Income Dynamics; RTI = Research Triangle Institute; RTP = Research Triangle Park
Source: own calculations.

CHAD-Ex optimizes the relational database for efficient storage of CHAD data by organizing time-activity data into respective hierarchies and associating detailed dairy with clearly defined location and activity codes.

CHAD-Ex provides a user-friendly and logical graphical user interface (GUI) that facilitates intuitive exploration of the time-activity data. It operates in a tab-list fashion that supports two ways of browsing the data: "flat-view" and "drill-down".

The GUI of CHAD-Ex allows dynamic query of different aspects of CHAD data according to the criteria set up on the fly. It also allows sequential presentation of detailed information on the found items which are hierarchically stored and linked.

CHAD-Ex provides instant saving of explored data set and also gives options for file transfer such as download or upload.

Furthermore CHAD-Ex provides a help module for convenient presentation of answers to frequently asked questions (FAQs), listing the names of data tables and column headings, as well as various codes used for classification of data. It provides a feedback interface to facilitate the exchange of comments and ideas.

Strength and application future of CHAD-Ex

CHAD-Ex organizes various time-activity data into different hierarchies. Thus, it allows easy and efficient query of information with dynamically set criteria. It also fosters statistical analyses on the data.

A particular strength of CHAD-Ex is its capability for effective storing and presenting longitudinal time-activity data. This feature may be very helpful for accomplishing exposure modeling studies designed for maintaining proper intra- and inter-individual correlations (Glen et al., 2008). Such studies are extremely useful for understanding the relationship between intra-individual variability and inter-individual variability in exposure analyses (Frazier et al., 2008; Isaacs et al., 2008, 2012; Xue et al., 2006).

CHAD-Ex is similar to the "harmonized" American Heritage Time Use Data (AHTUD; see Merz and Stolze, 2008), with which it shares a number of studies (George and McCurdy, 2011). CHAD-Ex may be more useful for exposure studies which assemble demographic cohorts to specific metropolitan area and then use conditional probability distribution to assign diary days of time use data to each modelled individual in these cohorts (Burke et al., 2001; Xue et al., 2006).

Summary

CHAD-Ex makes it easier for time use researchers to explore time-activity data stored in CHAD. It also facilitates the easy incorporation of new human activity data into CHAD. The powerful but yet flexible database structure of CHAD-Ex may point a way for evolving CHAD into a multi-national time use database and thus serving the global exposure research communities even better.

Disclaimer

This paper has been reviewed in accordance with EPA's internal procedures, and has been approved for publication. Mention of trade names or other commercial products does not constitute endorsement of their use by EPA.

Conflict of interest

The authors declare no conflict of interest. Staff of the U.S. Environmental Protection Agency developed CHAD Explorer (CHAD-Ex) using taxpayer-provided funds from the Agency's general research budget.

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A REVIEW OF PAKISTAN'S NATIONAL TIME USE SURVEY 2007

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This paper aims to highlight the salient features of Pakistan's first and only National Time Use Survey 2007 and the current issues that limit the utility this unique dataset. The Time Use Survey(TUS) was carried out by the Federal Board of Statistics Pakistan(FBS)with the aim to quantify the gendered distribution of productive time use and unpaid work in order to help draw women responsive policies, welfare programs and budgeting (FBS, 2008).

The survey is a national and provincial representative of the country at urban at rural levels. It excludes nearly 2 percent population in some specific areas due to time, access or security limitations. The survey provided a unique country wide dataset which is freely accessible and provides vast opportunities to the researchers, practitioners and professionals across the world. TUS data can be divided into two distinct segments, household segment and the individual time use diary segment.

The household segment enlists useful data regarding housing detail (e.g. tenure, access to public schools, healthcare, energy sources, public transport facilities) and socioeconomic status (e.g. household size, age, gender and rank of members, income level and sources, items of use, ICT and vehicle ownership).

The time diary segment enlists individual's socioeconomic details (e.g. skills, workforce participation, details about the nature of employment and enterprise, monthly income and sources etc.) and the past day's activity details from 4:00 am to 4:00 am.

Three main activities were listed for each of the forty eight 30 minute time slots in the diary through open ended questions. If the respondent reported more than one activity in 30 minute interval, the question was asked whether the activities were carried out successively or simultaneously. Later for analysis purpose, the activities were grouped into 123 detailed and 10 broad activity categories. An important component of diary segment 'Location Code 1 and 2' provides exclusive description of the human activity space. 'Location Code 1'identifies the broad facility / land use of activity duration while 'Location Code 2' is a description of the physical space (inside or outside) and specifically inquires about the mode of travel during activity, if any.

Sampling and data collection

Pakistan's total populations roughly comprise 60 percent rural and 40 percent residents. Both urban and rural people have been given equal representation in the survey according to their share in national population. Thus, from the sample size of 19600, nearly sixty percent (11706) were surveyed from rural households and remaining forty percent respondents (7660) were surveyed from the urban households. A routine three stage sampling procedure was applied to rep-

resent the data at provincial level. In this process, the whole country was divided into 1388 Primary Sampling Units (PSUs). Selection of survey sample from the PSUs is based on probability proportional to size method where a PSU with higher population size had the higher chances of selection for survey participant identification. Then PSUs are subdivided into Enumeration Blocks (EB) by lower, middle and upper income areas each with nearly 250 houses.

At the third stage, selection of households from EB is done with equal probability through systematic sampling with a random start. Every 16^{th} house is selected from urban and 12 households from rural EB. Same procedure is use for Labor Force Surveys, national census, elections and administrative tasks. The next additional step specific to TUS selected individuals for time use diary measurements from survey households. For this, the respondents were selected systematically through a selection table based on the age rank of household members. Using this selection table, younger members of household have slightly higher chances of participation. The reason behind it may be the higher participation of younger members in economic activities.

Household section information was asked from adult member of the household whereas the time use diary was surveyed from two respondents above 10 years of age from each household. The possible reason behind surveying younger population is to assess the prevailing practices of child labor and other socio cultural issues which reduce the female's response rate. FBS hired 120 field staff mostly comprising local female surveyors for the survey who sometimes made multiple visits to the houses accompanied by local political leaders. Since this was the first ever time use survey in the county, staff were trained before survey regarding the basic concepts, survey techniques, recording and coding of time based activities in the diary segment.

The data has been collected from face to face questionnaire interviews during the whole year throughout the weekdays and weekends. Generally, each day of the week carries 14 - 16 % of the survey questionnaires, but for Saturday, a relatively lesser nearly questionnaires (9 %) were filled due to the reason that it is a half working day in country and the past day for which information was asked, the Friday, is usually a full holiday for labor and farmers rather. After data collection, the filled questionnaires were digitized, check for consistency or referred back to field in case of inconsistency of information.

Methodological issues and challenges

A description of issues and challenges to the TUS's utilization in the country are given below whose redressing may increase its utility in future:

- There are some limitations in the activity classification for travel related analysis. For example, travel has been more thoroughly elaborated for the 'care' activity where the travel component has three specific activities as compared to only one travel activity in other activity lists which deserve a similar elaborative division. At the same time, the division of travel component under separate waiting or travelling answers is encouraged as it may tell

the actual waiting time which is useful for public transportation planning and efficiency assessment.

- 'With whom' activity detail is an increasingly popular and highly recommended component for time use surveys (Harvey and Spinney, 2012), however this information is not included in the activity diary questionnaire. I would argue in favor of using this information as it can provide useful insights into the mobility of dependent population like female, elderly and children. Since the country aims to evaluate the women's role in economic participation this activity will enable finding the real situation whether female are individual travelers to the work site or they tend to use an accompanying person for their mobility.
- The survey data does not describe any information regarding harmonization and correction of dataset for various anomalies of time use which may be provided as ancillary information with the dataset.
- Time use data collection and analysis is relatively new and novice technique in Pakistan. Only a handful of institutions, if any, educate their students about theoretical utility or practical collection and application of time diaries. Although creating summaries and descriptive statistics can be an easy task, advanced technique like survival analysis and hazard modeling is rarely used by researchers and professionals. There is a need to train government departments; university faculty and private professionals for increased use of freely available TUS information pool.
- The data has been made available in STATA file which is relatively lesser utilized software in the country. Few universities in Pakistan own or use the Stata as they are more accustomed to SPSS or other spreadsheet programs, thus a few students and researchers are able to explore large sized .dta file without SPSS.

Conclusion and recommendation

TUS 2007 is the first national time use survey account for Pakistan which has enabled a unique data source on gendered pattern in time use activities in the country. It gives an exhaustive level of details of vital activities like work, education, healthcare and media use. Since the data is available for free download for general public (GoP, 2012), it carries huge potential for measuring the patterns of activities across various social and economic disciplines. Although further improvements are needed in questionnaire contents in the measurement of household resources, activity description and provision of ancillary metadata with the main data file; it remains a useful data source for researchers and students alike.

The incorporation of a "for whom" component in activity classification can help better understand the dimensions of female economic productivity and unpaid labor contribution. The second occurrence of survey is not clear so far, it is important that the country keeps building on this information resource and its utilization consistently. Since a number of Asian countries are participating in time use surveys, the data can be useful for international comparison especially across Asian countries (Fisher, 2006, Bittman et al., 2004).

There is a need for organizing and harmonizing the data set with European and MTUS datasets for enhanced utility which would not only benefit to the country but also to the research across the world (Fisher et al., 2000).

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THE TIME USE DATA ACCESS SYSTEM – THE NEXT PHASE OF THE AMERICAN TIME USE SURVEY DATA EXTRACT BUILDER (ATUS-X)

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The American Time Use Survey (ATUS) is an ongoing time diary survey funded by the United States Bureau of Labor Statistics and fielded by the United States Census Bureau. Data collection began with some 20,000 interviews in 2003 and 14,000 responses have been collected each subsequent year. ATUS respondents are a nationally representative sample of persons aged 15 and older drawn from households who have concluded their participation in the Current Population Survey (CPS), the monthly labor force survey in the United States. For each activity during the day covered by the ATUS interview, respondents are asked what they were doing, where they were, and who was with them. Background information about the ATUS respondents and their households is collected as part of the ATUS interview. The ATUS public use files also include information collected during the household's final CPS interview. The survey is designed to permit the addition of modules on specific topics, such as the 2006-2008 Eating and Health Modules sponsored by the Economic Research Service of the United States De-

partment of Agriculture, the 2010 Well-Being Module sponsored by the National Institute on Aging, and the 2011 Leave Module sponsored by the U.S. Department of Labor Women's Bureau.

The American Time Use Survey Data Extract Builder (ATUS-X) gives users easy access to American Time Use Survey (ATUS) data through an online data access system (www.atusdata.org). The ATUS public use files are challenging for researchers to use, requiring a substantial initial investment before analysis can begin. By facilitating the creation of data files that are ready for analysis, ATUS-X is encouraging increased use of the ATUS data to address a range of important social and policy topics. The ATUS-X has accumulated 1,200 registered users who have made over 3,800 data extracts, including nearly 38,000 time use variables in those extracts. We also estimate that over 130 articles, chapters, working papers, and conference presentations have used ATUS-X, and, because many authors do not inform us of their publications or explicitly cite the extract system, this figure is certainly an undercount.

Version 2.4 of the American Time Use Survey Data Extract Builder (ATUS-X) incorporated 2010 ATUS data, and during the winter of 2011 we added 2010 Well-Being module data to the system. Version 2.5 of the ATUS-X, released in July 2012, includes recently made public 2011 ATUS data. To date, data from 2003-2011 have been incorporated into the system as well as information from the ATUS supplementary modules on Well-Being and Eating and Health. Information on secondary eldercare from the 2011 ATUS has already been added to the system. The addition of the 2011 Leave Module is pending.

Files for ATUS data linked to CPS education, food security and volunteer supplement data are available through the ATUS-X web site. We have created weights to accompany linked ATUS/CPS supplement data. In the future, we plan to make linked data available via the extract system.

A competitive five-year renewal application for the Time Use Data Access System (TUDAS) was funded in August by the National Institute of Child Health and Human Development. This project is a collaboration of the University of Maryland (U.S.), the University of Minnesota (U.S.), and the Centre for Time Use Research (Oxford, U.K.). This new funding will extend our work for another five years and permit incorporating the American Heritage Time Use data sets and Multinational Time Use Survey data from several European countries. We expect these additions to dramatically increase both cross-temporal and cross-national analysis of time use data. In light of our recent success securing funding to extend and expand the ATUS-X database, we will be redesigning our data extraction system to accommodate the different data structures characterizing the additional samples.

How people use their time, why individuals allocate their time as they do, and what consequences flow from these time use decisions are fundamental to the health, quality of life and effective functioning of a society. The potential of time use data for unlocking the black box of household decision-making is just being realized. Continuing this project for another five years and adding historical U.S. and selected European samples to the database as well as new func-

tionality to the extraction system will facilitate research on parental time with children, how time use influences health, household responses to changing economic conditions, and cross-national research on health and well-being in different cultural and policy settings.

Funding for this project is provided under a grant from the Eunice Kennedy Shriver National Institute of Child Health and Human Development, R01-HD053654. For more information visit www.atusdata.org or contact us via email at atusdata@umn.edu or hofferth@umd.edu.

NORDIC CONTACT NETWORK ON TIME USE SURVEYS

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Nordic statistical institutes have established contact networks in different statistical domains for cooperation. Time Use Surveys also have their own contact group. Experiences gained from conducting Time Use Surveys are shared in the contact network. The Nordic countries take turns in acting as the chair for the network for a term of three years. Finland is currently the chair for the Time Use Surveys network. In recent years, the network has convened annually. The latest meeting was in Oslo, Norway in September 2012.

Time Use Surveys have been conducted in the Nordic countries for a long time. Denmark was the first Nordic country to make a Time Use Survey in 1964. It was carried out by the Danish National Centre for Social Research. The next country was Norway, where the local statistical institute conducted its first Time Use Survey in 1970-1971. The first survey by Statistics Finland in the autumn of 1979 was largely based on the Norwegian model (Niemi 2000). Statistics Sweden made its first Time Use Survey in 1990-1991. It was in turn largely based on the Finnish example. Since then, the surveys have been repeated in each of these countries at least twice, approximately every ten years. Iceland is the only Nordic country that has not yet carried out a Time Use Survey. They have discussed the possibility to start conducting the survey.

Due to their history, the Norwegian, Finnish and Swedish surveys are quite similar. The Danish surveys differ somewhat from these in terms of methodology. Norway, Finland and Sweden have used diaries into which the respondents write down what they have done in their own words, while in Denmark, the surveys (apart from the 2001 survey) have been based on pre-classified diaries.

Eurostat, the Statistical Office of the European Communities, compiled recommendations for a Harmonised European Time Use Survey, HETUS in 2000 (Eurostat 2004). The Nordic countries have applied these recommendations varyingly in the two latest surveys. Finland and Denmark have used household samples in accordance with the recommendation; Norway and Sweden have mainly continued using samples of individual persons. The age limits have also differed.

The latest Time Use Survey was conducted in Denmark in 2008-2009, in Finland in 2009-2010, and in Norway and Sweden in 2010-2011. The Danish survey was conducted by Rockwool Foundation; the surveys in the other Nordic countries were conducted by the country's statistical institute. The interviews were conducted mainly by telephone in Norway and Sweden, and by telephone and visits in Finland. In Denmark, the data were, apart from telephone interviews, also collected via the web. The Danish sample was partially a panel sample, and it included people that had participated in the 2001 and 1987 surveys. In addition to time use, the Danish survey also examined consumption.

In the Nordic contact group meetings, the main discussion topics have been how to maintain response activity, coding, the quality of the data, and reporting.

Denmark and Norway used monetary incentives to motivate participation. Sweden and Finland also closely monitored response rates during the fieldwork.

In Finland, coding and saving were combined. Word abbreviations were used as saveable codes for main and secondary activities. In Sweden, all diaries were scanned; an activity search application and an application for quality control were used in coding. Denmark used pre-coded diaries, so no coding stage was required.

The effect of the different data collection methods on response activity and the quality of the data has been studied in different countries (Bonke & Fallesen 2010; Okkonen 2012; Väisänen 2012). No differences in quality were detected in Finland between the diaries that had been guided during visits or over the telephone. In Denmark, the quality of web diaries was better than that of telephone interviews.

Norway, Sweden and Finland included a question at the end of the diary concerning the pleasantness of the activities. In Norway and Sweden, the questions covered both the most and least pleasant activity, in Finland only the most pleasant activity.

A weekly diary concerning paid work included in the Eurostat recommendations was only used in Finland.

A pre-coded so-called light diary was also tested in Finland and Sweden during the collection of the actual diary, in order to compare whether different diaries produce similar results concerning the population’s time use.

All three Nordic countries have already reported their main results. Finland's report was published in Finnish in 2011 and in English in 2012 (Pääkkönen and Hanifi 2012). Norway's (Vaage 2012), Sweden's (SCB 2012) and Denmark's (Bonke 2012) reports were published in 2012. Statistics Finland's Welfare Review and Norway's statistical institute's Samfunnsspeilet magazine published extensive special issues concerning time use in the autumn of 2012.

In addition, articles have been compiled concerning the results from different countries and they have been presented, for instance, in IATUR conferences. You can also find online tables concerning time use on the websites of Finland's, Norway's and Sweden's statistical institutes.

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Book notes

by Kimberly Fisher

Cain L. P. and D. G. Paterson (eds.)
The children of eve – Health and well-being in history (2012)

Publisher: Wiley-Blackwell
ISBN: 978-1-4443-3689-4
Website:
http://eu.wiley.com/WileyCDA/WileyTitle/productCd-1444336894,descCd-authorInfo.html
Languages Available: English

This book undertakes a long-term look at the social, demographic and economic factors which underlie the present trends affecting population well-being. The opening chapters adopt a long-term historical perspective. The time use discussion emerges in the later chapters 7 (the changing family), 8 (health and well-being), and particularly 9 (macroeconomic effects of the industrial transition). Chapter 9 uses Multinational Time Use Study data to explore work-life balance issues and time in domestic work.

Cyrino, R. and P. Dias (eds.)
Mulheres executives – A divisao do trabalho domestico a luz dos estereotipos (2012)

Publisher: Fino Traço Editora
ISBN: 978 8580 540697
Website:
http://www.finotracoeditora.com.br/livros/CYR001/9788580540697/mulheres-executivas-a-divisao-do-trabalho-domestico-a-luz-dos-estereotipos.html
Languages Available: Portoguese

This book contains core research from a PhD thesis examining gender relations in households of women who work in senior management and high-status professional jobs. The author demonstrates that even women who hold significant power in the job market nevertheless perform a disproportionate share of unpaid domestic work.

Duhigg, C. (ed.)
The power of habit – Why we do what we do and how to change (2012)

Publisher: William Heinemann
ISBN: 978-0434020362
Languages Available: English

The author uses his experience as a journalist to present research into the neurological and psychological understandings of the processes by which people learn, develop

and change their habits. While the author does not make much direct use of time use data, and while this book aims to help readers to amend their routines to achieve goals, the book does offer insight into the factors shaping daily behaviours.

Inbakaran C. and M-L. Van Der Klooster (eds.)
2011 Time use in Australia, United States and Canada (2012)

Contributing Authors: Mareggi, M., Harvey, A. S., Spinney, J., Robinson, J. P., Godbey, G., Giannelli, G. C., Mangiavacchi, L., Piccoli, L., Brzozowski, J-A., Martino, A. E., Vitartas, P., Ellwood, M., Wolfteich, C. E., Sanchis, R. G., Francavilla, F., Grotkowska, G. and M. Socha
Publisher: Deakin University
ISBN: 978-1906040895
Languages Available: English

This short book offers brief summaries of a number of contemporary time use research projects in Australia, Canada, Ecuador, Italy, Poland, Spain, and the United States of America. Many of the pieces raise methodological challenges: how we measure urban behaviour in the context of spaces in which behaviour takes place; how we code activities transcending the boundaries between paid and unpaid work or between secular and sacred domains; how we best measure sports participation, adult care or the emotions associated with activities; how we include measure of unpaid work in national accounts; how we identify the impact of communication technologies on daily behaviour.

Lelord F. (ed.)
Hector finds time (2012)

Publisher: Gallic Books
ISBN: 978-1906040895
Languages Available: English

This popular literature book offers an English translation of the original 2006 French book Le Nouveau Voyage d'Hector : A la Poursuite du Temps Qui Passe, a story about a psychiatrist dealing with concerns about his time while listening to patients with time-related concerns of their own. While this is not an academic text, the book explores issues related to lived time use patterns, and thus may offer engaging leisure reading for time use researchers.

Mückenberger, U. (ed.)
Lebensqualität durch Zeitpolitik –Wie Zeitkonflikte gelöst werden können (2012)

Publisher: Hans-Böckler-Stiftung, Edition Sigma
ISBN: 978-3-8360-8742-1
Languages Available: German

This book explores how time use features in industrial conflicts, making a particular contribution to the literature by contrasting the time-related issues for employers, employees, and other parties affected by labour disputes. Mückenberger uses both theoretical discussion and empirical evidence to demonstrate the contribution of time use patterns to the quality of life experienced by working people. He then sets out strategies by which the time and efficiency needs of companies can be reconciled with the time

balance needs of employees, creating win-win scenarios for all parties in labour disputes over time-related issues.

McDonald, P. and E. Jeanes (eds.)
Men, wage, work and family (2012)

Contributing Authors: Brown, P. and H. Perkins
Publisher: Routledge
ISBN: 978-0415893763
Website:
http://www.routledge.com/books/details/9780415893763/
Languages Available: English

This book explores a range of issues arising for working men in a range of countries in relation to balancing employment and home commitments. The majority of chapters deal with a range of issues relevant to the time use research community in a general way. One chapter by Peter Brown and Helen Perkins, "Happiness Under Pressure: The Importance of Leisure Time Among Fathers in Dual Earner Households," uses experience sampling and qualitative interview time use data, to examine work and family life conflicts experienced by Australian fathers.

Höjer, M., Gullberg, A. and R. Pettersson (eds.)
Images of the future city – Time and space for sustainable development (2011)

Publisher: Springer
ISBN: 978-9400706521
Website:
http://www.ebook3000.com/Images-of-the-Future-City--Time-and-Space-For-Sustainable-Development_123416.html
Languages Available: English

This book draws on a variety of data to project what life in Stockholm, Sweden, might be like if lifestyles shifted to use substantially fewer resources to reduce the impact of human behaviour on climate change. The authors consider patterns of eating, housework and domestic production, paid work, transport, and other patterns of time use as a central issue in their analysis.

World development report 2012 – Gender equality and development (2011)

Contributing Authors: Revenga, A., Shetty, S., Benveniste, L., Coudouel, A., Das, J., Goldstein, M., Muñoz Boudet, A. M. and C. Sánchez-Páramo
Publisher: World Bank
Website:
http://go.worldbank.org/CQCTMSFI40
Languages Available: Available: Arabic, Chinese, English, French, Portuguese, Russian, Spanish

This report maps changes in gender relations across the world with an aim to documenting the extent and modes of manifestation of gender inequality as well as provid-

ing data to monitor gender equality as a means to improving development and quality of life around the globe. Time use information appears sporadically throughout the report in sections covering paid work, total work, the contribution of unpaid domestic production to national and the global economy, and parenting styles and childcare.