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INEQUALITY AND THE TIME-STRUCTURE OF HOUSEHOLD INCOME IN ISRAEL[†]

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Abstract

The aim of this paper is to empirically evaluate the effect of the length of the accounting period on households' income inequality in Israel. There are three main findings: (1) the analysis of the impact of the account period on the Gini index of inequality can be done in a way which is identical to analyzing the effect of the accounting period on the coefficient of variation; (2) Changing the accounting period from a month to three months decreases, on average, the Gini index of inequality by about 1.7%. Furthermore, the Gini index calculated from a three-month accounting period was 1.7%-4.4% higher than the index based on a twelve-month period. The change in the accounting period from twelve months to three months accounts to ten to fifty percent of the increase in inequality in the last two decades, depending on the type of income considered. (3) The above relationship is stable over the years but is sensitive to the definition of income.

JEL categories: C10, J6, O15

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Inequality and the time-structure of household income in Israel

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The fact that inequality declines, when the period over which income is measured increases, is, by now, well known and well documented (Creedy, 1979, 1991; Burkhauser and Poupore, 1997; Gibson, Huang, and Rozelle, 2001). Wodon and Yitzhaki (2003) supply a formal proof with respect to the occurrence of this fact. However, all one can prove is that inequality should decline but the magnitude of the decline has to be found empirically. In some sense, we have a law, which is similar to a physical law, known to any amateur photographer. When taking the picture of moving targets, the shorter the time the shutter is open, the sharper is the picture. The actual decline of the quality of the picture depends on other factors. However, it is not clear that the economist should be interested in the sharpest picture, and different considerations may lead to different pictures.

The aim of this paper is to empirically evaluate the effect of the length of the accounting period on households' income inequality in Israel. There are three main findings: (1) the analysis of the impact of the accounting period on the Gini index of inequality can be done in a way which is identical to analyzing the effect of the accounting period on the coefficient of variation; (2) a change in the accounting period from a month to three months decreases, on average, the Gini index of inequality by about 1.7%. Changing the accounting period from three to twelve months decreases the Gini by 1.7%-4.4%, depending on the definition of income used. The implications of those magnitudes is that between ten to fifty percent of the recorded growth in inequality in Israel over a period of twenty years can be attributed to the reduction of the accounting period from a year to three months. (3) The above relationship is stable over the years but is sensitive to the definition of income.

In the mid-eighties, the Israeli Central Bureau of Statistics (ICBS) initiated substantial changes in its *Household Expenditure* and *Household Income Surveys*. One of the more noteworthy changes was the reduction of the accounting period, for income data, from twelve months to only three. The recall effect phenomena[1], that normally takes place the longer the accounting period, was heightened by the rising inflation rates that were common in Israel in the first half of the nineteen-eighties. Examination of the income data received in the surveys in the early eighties showed that only a quarter of the data were received from actual salary slips; another fifth were recorded based on the memory of the respondent and about one half of the data had to be estimated by the economists in the ICBS, using external data to impute the incomes. The amount of imputations needed for the current month was only 10%, whereas the share of imputations for the earliest month (the earliest month being the one from 12 months before) was 70%. The combination of memory lapse in periods of high inflation and rising shares of imputed data eventually led the ICBS to shorten the accounting periods in the survey. This fact alone accounted for anywhere between 11%-57% of the total change in inequality (based on the definition of income) during the 20-year period of 1979-1999.

The structure of the paper is as follows: Section 2 describes the basic methodology on which the analysis is based. Section 3 describes the data and performs the decomposition of a quarterly income into monthly income, for the year 1999. Section 4 replicates the analysis of Section 3, this time decomposing yearly income into monthly income. Section 5 provides an approximation formula, while Section 6 presents sensitivity analysis, by decomposing adult-equivalent incomes.

Section 2: A Brief summary of the methodology

This section presents the relationship between the values of the Gini index of inequality of income that is measured over a period of time, to the Gini indices of inequality measured over a sub-period of time. The methodology we rely on is presented in Wodon and Yitzhaki (2003). Yitzhaki (2003) relates the methodology to other properties of the Gini. The statistical tests we are using are developed in Schechtman and Yitzhaki (2003). Following is a brief summary of the methodology.[2]

[1] Recall effect: Time generally reduces ability to recall facts or events. Memory fades, resulting in respondents having more difficulty recalling an activity when there is a long time period between an event and the survey. For example, Huang (1993) found the increase in precision obtained by increasing sample size and changing from a four-month reference period to a six-month reference period would not compensate for the increase in bias from recall loss.

[2] The reader interested in proofs and/or additional properties is referred to the above-mentioned paper.

Let $Y_1, Y_2, \ldots, Y_T$ be the income distributions in T periods. The income distribution defined over the overall period is $Y_0 = \sum_{t=1}^{T} Y_t$. Denoting by $F(Y_t)$ the cumulative distribution and μ_t the expected income in period t, the Gini coefficient in period t (t=0,…,T) (Lerman and Yitzhaki, 1984) is:

$$G_t = 2\,\mathrm{cov}(Y_t, F(Y_t)) / \mu_t \ . \tag{1}$$

Denote by $\Gamma_{ij} = \frac{\mathrm{COV}(Y_i, F(Y_j))}{\mathrm{COV}(Y_i, F(Y_i))}$, i, j = 0, 1, 2, …,T the Gini correlation between incomes measured in periods i and j, or between income from one period and overall income. As discussed in Schechtman and Yitzhaki (1987, 1999), the properties of the Gini correlations are a mixture of Pearson's and Spearman's correlation coefficients. In particular, Γ_{ij} is bounded by minus one and one, but Γ_{ij} is not necessarily equal to Γ_{ji}. Define $D_{i0} = \Gamma_{i0} - \Gamma_{0i}$, for i=1,…,T (here, the Gini correlations are taken between the income in each period and the overall income), and $a_t = \mu_t/\mu_0$, where $\mu_t > 0$ is the expected income in period t, while a_t share of the income from period t in the overall income.

Proposition:

Let $Y_0 = \sum_{t=1}^{T} Y_t$, $a_t = \mu_t / \mu_0$, then

$$G_0^2 - G_0 \sum_{t=1}^{T} a_t D_{t0} G_i = \sum_{t=1}^{T} a_t^2 G_t^2 + \sum_{t=1} \sum_{t \neq j} a_t a_j G_t G_j \Gamma_{tj} \ . \tag{2}$$

If $D_{t0} = 0$, for t=1, …, T and $\Gamma_{tj} = \Gamma_{jt}$, then:

$$G_0^2 = \sum_{t=1}^{T} a_t^2 G_t^2 + 2 \sum_{t=1}^{T} \sum_{t<j} a_t a_j G_t G_j \Gamma_{tj} \ . \tag{3}$$

Equation (3) is identical in its structure to the decomposition of the coefficient of variation, except that every term that is defined in the context of the variance (coefficient of variation, Pearson's correlation coefficient, variance) is substituted by the appropriate

Gini defined term. For it to hold, the Gini correlations between each pair of variables Y_0 ,…, Y_T must be equal. Schechtman and Yitzhaki (1987) show that a sufficient (but not a necessary) condition for $\Gamma_{ij} = \Gamma_{ji}$ is that the variables are exchangeable up to a linear transformation. Examples of such distributions are the multinormal and the multivariate lognormal, provided that $\sigma_i = \sigma_j$, where σ is the logarithmic standard deviation. If the Gini correlations between pairs of variables are not equal, we need to use equation (2), where each "violation" of the equality of the Gini correlations is captured by an additional term in the decomposition (hence, we can treat each violation separately and evaluate its effect on the decomposition; in particular we can see whether the violation tends to increase or decrease overall inequality). Since $a_i < 1$, $\Gamma_{ij} \leq 1$ for all i,j it is easy to see that the shorter the accounting period is, the higher the inequality will be. Yitzhaki (2003) (proposition 3, 303) shows that exchangeability up to a linear transformation is a sufficient condition for (3) to hold but it is not a necessary one. In any case, as will be shown in the empirical part, (3) holds for family income in Israel.

The next section presents statistical tests on whether the two Gini correlations are equal.

Section 3: Empirical results – 1999

Income data for this paper were extracted from the Household Expenditure Surveys (HES), conducted in 1979/80 and 1998/99 by ICBS. HES were first performed in the early 1950's; until 1997 they took place approximately once every five years. Since 1997, ICBS has conducted the survey on an annual basis, covering nearly all of the household population. The survey aims to obtain data on the components of household budgets, as well as additional data that characterize various aspects of the living standard of households, such as consumption patterns, leisure activities and entertainment, level and composition of nutrition, level and composition of income and housing conditions. In addition, the survey is used for market research, for construction of models to predict consumer behavior, for research on the effect of taxes among the various population groups, etc. One of the most important uses of the survey is to determine weights for the consumption basket of the CPI.

As of 1997, the survey population includes 95% of the urban and non-urban household population. The investigation unit is the household, i.e., a group of people living in the same dwelling most days of the week with a shared budget for food expenditures.

Data were collected from each household in an integrated fashion, in the following ways: (1) a questionnaire on household structure – filled out by the interviewer, providing basic demographic and economic data on each member of the household; (2) a bi-weekly diary – in which the household independently records each member's daily expenditures over a period of two weeks; (3) a questionnaire on larger expenditures and on *income* – filled out by the interviewer on the basis of household reporting, related to the three month period preceding the interview date.

Estimates from the bi-weekly diaries and quarterly questionnaires are "inflated" into yearly expenditures and divided into monthly expenditure estimates.

Of the 7,625 dwellings sampled in 1999, 711 (9.3%) should not have been investigated (not belonging to survey population); 7,047 households inhabited the remaining 6,914 dwellings; 5,921 households (84.0%) participated in the final survey estimates[3].

Table 1 below presents the components of the decomposition, according to equation (2), of the quarterly incomes into the monthly contributions. We concentrate on after-tax income per household for the year 1999. The sum of incomes over three months is referred to as quarterly income, t=0 is the last month before the visit of the enumerator; t-1 and t-2 are the previous months accordingly.[4] The first line presents the monthly Ginis and the quarterly Gini. The average monthly Gini is 0.3962 which is 1.7 percent greater than the quarterly Gini. Also the differences among the monthly Ginis are not significant. The second line presents the share of the monthly income in the quarterly income, which is as expected, approximately a third.

The second part of the Table presents the Gini correlations between the monthly incomes, and between monthly incomes and quarterly income. It is interesting to see that

[3] For the purpose of comparison with the HES of 1979/80 we excluded the households living in East Jerusalem and rural settlements. The final data set for 1999 consisted of 5,514 observations.
[4] Note that the three months period is moving along the year, with approximately 1/12 of the households investigated each month. Actually, the data cover a 15-month period.

the correlations are very high, all of them above 0.92. We will return to this point later. The third part of the Table presents the contribution of different terms of equation (2). The term that distinguishes the decomposition of the Gini from the decomposition of the coefficient of variation, $G_O \Sigma a_i D_{iO} G_i$ is adding 0.0006, which is less than 0.2 percentage points to the Gini and about one tenth of the standard error of the Gini. Hence, we can safely ignore this term and claim that the decomposition of the Gini of household income into monthly incomes can be performed by equation (3) for any practical purpose. Note, however, that this conclusion is not based on theoretical ground and therefore, one has to test its validity for each set of data. An additional observation that comes from the last line of Table 1 is the role of correlations between monthly incomes that overshadows the contribution of the Ginis of the monthly incomes (0.1 vs. 0.05). This result is expected due to the high level of Gini correlations among the monthly incomes.

Table 1: The Components of Gini by Monthly After-Tax Income per Household*
(Source: Household Expenditure Survey, 1999)

	Gini indices of inequality (G_i) and income shares (a_i)				
	Quarter	t=0	t=-1	t=-2	
Gini Index	0.38942	0.39798	0.39658	0.39406	
St. Error	(0.0054)	(0.007)	(0.0069)	(0.0062)	
Income share	1	0.3363	0.3329	0.3307	
	Gini Correlations matrix (Γ_{ij})				
i/j	Quarter	t=0	t=-1	t=-2	
Quarter	1	0.9735	0.9807	0.9831	
t=0	0.9801	1	0.9448	0.9245	
t=-1	0.9850	0.9454	1	0.9463	
t=-2	0.9834	0.9420	0.9575	1	
	G_O	G_O^2	$G_O \Sigma a_i D_{iO} G_i$	$a_i^2 G_i^2$	$\Sigma\Sigma a_i a_j G_i G_j \Gamma_{ij}$
Quarter	0.3894	0.1516	0.0006	0.0523	0.0987

* In parenthesis, standard errors calculated by the jackknife procedure (Schechtman and Yitzhaki (2003)).

Tables 2 and 3 below present the formal supporting arguments for the conclusions reached from Table 1. Table 2 presents the differences between the Gini correlations of monthly incomes among themselves and between them and the quarterly income. As can be seen, the maximum difference is lower than 0.02, which is negligible. Moreover, the difference in correlations between the monthly incomes and quarterly income, which are the differences that may invalidate the quadratic nature of the decomposition are lower than 0.007, which is practically zero. Table 3 presents the test statistics, all of them being far from significant.[5] This is a surprising result given the large size of the sample. The conclusions reached here are totally different from the conclusions reached in Wodon and Yitzhaki (2003). But there are major differences between the data sets: Wodon and Yitzhaki used quarterly data of Mexican incomes of *individuals*, where movement from employment to unemployment is high, while here *households'* incomes are used, with more stable employment patterns. Also, Wodon and Yitzhaki (2003) did not test the statistical significance of their findings. We will return to this point when we perform sensitivity analysis of the findings.

Table 2: Differences in Gini Correlations (Γ_{ij}-Γ_{ji})

i/j	Quarter	t=0	t=-1
t=0	0.0066		
t=-1	0.0043	0.0006	
t=-2	0.0003	0.0175	0.0112

Table 3: Test-Statistics for Differences in Gini Correlations

i/j	Quarter	t=0	t=-1
t=0	1.4047		
t=-1	1.1494	0.1195	
t=-2	0.3505	1.2152	0.9550

The high level of the Gini correlations is a bit surprising. Schechtman and Yitzhaki (1987) have pointed out that the properties of the Gini correlations are a mixture of Spearman's and Pearson's correlation coefficients. Table 4 below presents the Spearman and Pearson correlation coefficients. As can be seen the Gini correlations are almost identical in magnitude to the appropriate Spearman correlation coefficients but may sharply differ from the Pearson correlation coefficients.[6] While the Gini and Spearman correlation coefficients are above 0.92 all monthly Pearson correlation coefficients are lower than 0.67. This result points out that relying on linear correlation

[5] The test statistic is the difference in Gini correlations divided by its standard error. It is asymptotically normally distributed (Schechtman and Yitzhaki (2003).

[6] In general, the Gini correlation can be higher or lower than Spearman's or Pearson's correlation coefficients.

may be misleading when one deals with distributions that deviate from normality. As shown in Schechtman and Yitzhaki (1999), while the range of Spearman and Gini correlation coefficients lies always between –1 and 1, the range of the Pearson correlation coefficient may be seriously affected by the shape of the marginal distributions. A relevant example is provided by De Vaux (1976) who shows that, provided the underlying marginal distributions are lognormal, then the range of Pearson's correlation coefficient is [-0.368, 1]. The results are unexpected: the difference (Table 5) between Spearman's and Pearson's correlations can reach 0.4. It indicates that although the shape of the marginal distributions should not affect the upper bound of Pearson's correlation coefficient, its magnitude can be seriously affected by relying on a linear correlation coefficient. [7]

Table 4: Pearson and Spearman Correlations Coefficients
Pearson in the lower left triangle, Spearman in the upper right triangle.

	Quarter	t=0	t=-1	t=-2
Quarter		0.977	0.983	0.982
t=0	0.877		0.945	0.939
t=-1	0.869	0.657		0.958
t=-2	0.848	0.650	0.560	

Table 5: Difference Between Spearman and Pearson Correlations
Difference = Spearman_{ji} - Pearson_{ij}

	Quarter	t=0	t=-1
t=0	0.101		
t=-1	0.114	0.288	
t=-2	0.133	0.288	0.398

We replicated the analysis for the year 1998, and got almost identical results. To save space the results for 1998 are not presented.[8]

[7] It is worth noting that Behrman and Taubman (1989) find that the estimated inter-generational correlation of parental income and offsprings is 0.58 when ten years of earnings are used, compared to 0.37 for a single year. The results of this paper hint that Gini and Spearman correlation coefficients may be of higher values. Bowles and Gintis, 2002, offer additional correlations to suspect.
[8] They are available from the authors upon request.

Section 4: Decomposition of 12 month income into monthly components

To check whether the same findings hold for a longer period of investigation, we turned to the Household Expenditure Survey of 1979/80, which is based on twelve-month incomes, with the investigation being spread over the calendar year.[9] Table 6 is identical in structure to Table 1, except for the length of the accounting period. The first line reports the yearly and monthly Ginis, with t=0 indicating the month prior to the visit of the enumerator. As can be seen, the farther the visit of the enumerator, the higher is the Gini coefficient. We do not know whether this finding is of any significance, especially since the year 1979 was with high inflation. However, the yearly Gini (0.3399) is lower than the average monthly Gini (0.3643) by seven percent. This result is consistent with the finding from data on 1999 that the Gini of quarterly income is 1.7 percent higher than the Gini of monthly income. The shares of monthly income in the yearly income are reported on the third line. They are evenly spread, except for the last month of the investigation.

The next part of the Table 6 reports the Gini correlations. The values of correlations of monthly incomes with the twelve-month incomes continue to be high, the lowest being 0.86. When looking at correlations between monthly incomes, as expected, the greater the time gap between the months, the lower the correlation. It is interesting to note, however, that the correlations between t=0, t=-1 and t-2 are similar in magnitude to the correlations reported in 1999.

[9] Each household is asked about its income in the last twelve months before the visit of the interviewer. The visits of the interviewers are uniformly spread over the year.

Table 6: The Components of Gini by Monthly After-Tax Income per Household
(Source: Household Expenditure Survey, 1979-80)

	Gini indices of inequality (G_i) and income shares (a_i)												
	Annual	t=0	t=-1	t=-2	t=-3	T=-4	t=-5	t=-6	t=-7	t=-8	t=-9	t=-10	t=-11
Gini Index	0.3399	0.3483	0.3522	0.3518	0.3507	0.3534	0.3574	0.3613	0.3648	0.3658	0.3757	0.3810	0.4097
St. Error	(0.0072)	(0.0074)	(0.0077)	(0.0074)	(0.0073)	(0.0073)	(0.0073)	(0.0073)	(0.0073)	(0.0073)	(0.0081)	(0.0073)	(0.0068)
Income share	1	0.0825	0.0813	0.0812	0.0811	0.0820	0.0820	0.0820	0.0816	0.0817	0.0817	0.0835	0.0995
	Gini Correlations matrix (Γ_{ij})												
i/j	Annual	t=0	t=-1	t=-2	t=-3	T=-4	t=-5	t=-6	t=-7	t=-8	t=-9	t=-10	t=-11
Annual	1	0.941	0.936	0.945	0.949	0.954	0.949	0.949	0.945	0.942	0.931	0.915	0.874
t=0	0.935	1	0.935	0.923	0.908	0.886	0.877	0.876	0.865	0.851	0.834	0.818	0.791
t=-1	0.933	0.926	1	0.933	0.908	0.896	0.876	0.862	0.856	0.853	0.827	0.810	0.764
t=-2	0.943	0.916	0.933	1	0.931	0.908	0.895	0.874	0.868	0.863	0.837	0.816	0.768
t=-3	0.945	0.904	0.902	0.933	1	0.929	0.915	0.897	0.878	0.868	0.843	0.827	0.765
t=-4	0.948	0.887	0.899	0.908	0.932	1	0.936	0.910	0.886	0.883	0.854	0.837	0.777
t=-5	0.945	0.869	0.873	0.892	0.904	0.928	1	0.929	0.904	0.886	0.859	0.831	0.770
t=-6	0.949	0.866	0.857	0.874	0.892	0.900	0.914	1	0.926	0.907	0.885	0.850	0.774
t=-7	0.944	0.854	0.850	0.861	0.865	0.878	0.901	0.918	1	0.929	0.895	0.865	0.778
t=-8	0.940	0.844	0.856	0.859	0.860	0.868	0.877	0.902	0.926	1	0.914	0.879	0.773
t=-9	0.933	0.831	0.834	0.840	0.836	0.842	0.844	0.884	0.896	0.908	1	0.905	0.795
t=-10	0.915	0.814	0.809	0.809	0.816	0.825	0.826	0.853	0.865	0.881	0.913	1	0.809
t=-11	0.866	0.786	0.771	0.772	0.764	0.783	0.770	0.789	0.788	0.794	0.818	0.846	1
	G_O		**G_O^2**		**$G_O \Sigma a_i D_{iO} G_i$**		**$a_i^2 G_i^2$**		**$\Sigma\Sigma a_i a_j G_i G_j \Gamma_{ij}$**				
Annual	0.3399		0.1155		-0.0004		0.0112		0.1071				

The last line reports the decomposition according to equation (2). The first thing worth noticing is the value of $G_O \Sigma a_i D_{iO} G_i$, which is negative but almost equal to zero. Again, for any practical purpose we can conclude that the decomposition of the Gini of the twelve-month income into its monthly components follows the same procedure of the decomposition of the coefficient of variation, which is identical to the method presented in (3). Since the number of periods is larger, almost ninety percent of the twelve-month inequality comes from the last term, $\Sigma\Sigma a_i a_j G_i G_j \Gamma_{ij}$ that is affected by the correlations between monthly incomes.

Table 7 is a replication of Table 2, reporting the differences between Gini correlations. The most important components are the difference in correlations between the twelve-month and the monthly incomes. As can be seen, they are very close to zero. On the other hand, the differences between Gini correlations of monthly incomes can reach, in extreme cases, up to four percentage points.

Table 7: Differences in Gini Correlations (Γ_{ij}-Γ_{ji})

i/j	Annual	t=0	T=-1	t=-2	t=-3	t=-4	t=-5	t=-6	t=-7	t=-8	t=-9	t=-10
t=0	-0.007											
t=-1	-0.003	-0.008										
t=-2	-0.001	-0.006	0.000									
t=-3	-0.004	-0.004	-0.005	0.002								
t=-4	-0.006	0.001	0.003	0.000	0.003							
t=-5	-0.004	-0.007	-0.003	-0.003	-0.011	-0.009						
t=-6	-0.001	-0.009	-0.005	0.000	-0.005	-0.010	-0.016					
t=-7	-0.001	-0.011	-0.006	-0.007	-0.012	-0.008	-0.004	-0.008				
t=-8	-0.002	-0.006	0.003	-0.004	-0.008	-0.015	-0.009	-0.005	-0.004			
t=-9	0.001	-0.002	0.007	0.003	-0.007	-0.013	-0.015	-0.001	0.001	-0.006		
t=-10	0.000	-0.004	-0.002	-0.007	-0.011	-0.012	-0.006	0.004	0.000	0.001	0.008	
t=-11	-0.008	-0.006	0.007	0.004	-0.001	0.005	0.000	0.015	0.011	0.021	0.023	0.037

Table 8: Test-Statistics of Differences in Gini Correlations

i/j	Annual	t=0	T=-1	t=-2	t=-3	t=-4	t=-5	t=-6	t=-7	t=-8	t=-9	t=-10
t=0	-2.374											
t=-1	-0.797	-1.857										
t=-2	-0.612	-1.513	0.063									
t=-3	-2.664	-0.805	-0.562	0.554								
t=-4	-1.836	0.183	0.367	0.066	0.560							
t=-5	-0.883	-0.695	-0.272	-0.413	-1.846	-1.248						
t=-6	-0.322	-1.745	-0.453	-0.039	-0.774	-1.220	-1.241					
t=-7	-0.767	-1.679	-0.622	-1.150	-1.914	-0.860	-0.651	-2.001				
t=-8	-1.445	-1.059	0.663	-0.694	-1.646	-1.774	-1.156	-0.960	-0.809			
t=-9	0.688	-0.214	0.556	0.261	-0.689	-1.147	-0.968	-0.124	0.076	-0.755		
t=-10	-0.030	-0.587	-0.173	-1.008	-1.058	-1.394	-0.458	0.435	-0.013	0.208	0.739	
t=-11	-3.036	-0.747	0.686	0.531	-0.199	0.765	0.028	2.261	1.473	3.526	2.080	4.957

Table 8 above presents the test statistics for the differences in Gini correlations. Most of the differences in correlations are not significant. Of the twelve-month monthly differences in correlations only four out of twelve are significant with low values of the statistics, but all the differences are lower than one percentage point. Since the size of the sample is large (n=2,271) it is not surprising that some of the differences in correlations are significant. The important point is that they do not change the nature of the decomposition in any important way. When looking at the differences in monthly correlation the percentage of significant differences is relatively smaller, some of the differences being with opposite signs so that they cancel the effect of each other and we can safely conclude that even when we are dealing with a yearly income, the Gini can be decomposed in a way which is similar to the decomposition of the coefficient of variation.

To see whether the Gini correlations continue to behave like Spearman correlation coefficients, Table 9 presents the Spearman and Pearson correlation coefficients, while Table 10 presents the differences between the two correlation coefficients. As can be seen the Spearman correlation coefficients are higher than the appropriate Pearson correlation coefficients. However, the highest difference is eight percentage points, which is much lower than the differences detected in 1999 (forty percentage point). Comparison of the Gini correlations to Spearman and Pearson correlation coefficients shows that the Gini correlation coefficients are closer to the magnitudes of the Spearman correlation coefficients. This implies that the decline of the Gini coefficient as a result of increasing the accounting period should be expected to be slower than the decline of the coefficient of variation.

Table 9: Pearson and Spearman Correlations

Pearson in the lower left triangle, Spearman in the upper right triangle.

	Annual	t=0	t=-1	t=-2	t=-3	t=-4	t=-5	t=-6	t=-7	t=-8	t=-9	t=-10	t=-11
Annual		0.940	0.935	0.944	0.947	0.954	0.948	0.951	0.942	0.941	0.926	0.912	0.868
t=0	0.933		0.934	0.922	0.909	0.895	0.881	0.880	0.864	0.856	0.839	0.823	0.790
t=-1	0.932	0.922		0.936	0.912	0.905	0.883	0.869	0.859	0.856	0.833	0.815	0.774
t=-2	0.936	0.905	0.918		0.936	0.919	0.901	0.881	0.866	0.865	0.838	0.817	0.775
t=-3	0.935	0.891	0.887	0.907		0.937	0.916	0.899	0.875	0.867	0.844	0.830	0.773
t=-4	0.938	0.872	0.882	0.881	0.904		0.942	0.914	0.890	0.883	0.854	0.840	0.788
t=-5	0.931	0.855	0.859	0.867	0.876	0.894		0.934	0.906	0.890	0.862	0.843	0.783
t=-6	0.936	0.854	0.845	0.854	0.882	0.882	0.886		0.930	0.914	0.894	0.864	0.797
t=-7	0.937	0.851	0.839	0.861	0.851	0.863	0.876	0.891		0.937	0.902	0.875	0.793
t=-8	0.935	0.836	0.847	0.847	0.850	0.858	0.858	0.878	0.899		0.921	0.890	0.797
t=-9	0.902	0.797	0.801	0.806	0.800	0.809	0.806	0.831	0.848	0.865		0.921	0.821
t=-10	0.899	0.796	0.793	0.790	0.794	0.801	0.800	0.818	0.836	0.853	0.846		0.844
t=-11	0.841	0.762	0.735	0.737	0.728	0.747	0.735	0.742	0.749	0.747	0.743	0.777	

Table 10: Difference Between Spearman and Pearson Correlations

Difference = Spearman_{ji} - Pearson_{ij}

	Annual	t=0	t=-1	t=-2	t=-3	t=-4	t=-5	t=-6	t=-7	t=-8	t=-9	t=-10
t=0	0.007											
t=-1	0.003	0.012										
t=-2	0.008	0.017	0.017									
t=-3	0.012	0.018	0.025	0.030								
t=-4	0.016	0.024	0.023	0.039	0.034							
t=-5	0.017	0.026	0.024	0.035	0.040	0.049						
t=-6	0.015	0.026	0.024	0.027	0.017	0.032	0.047					
t=-7	0.005	0.012	0.020	0.004	0.023	0.027	0.029	0.039				
t=-8	0.006	0.020	0.009	0.018	0.017	0.026	0.032	0.036	0.038			
t=-9	0.024	0.042	0.032	0.032	0.044	0.045	0.057	0.063	0.054	0.056		
t=-10	0.013	0.027	0.022	0.027	0.036	0.039	0.043	0.046	0.039	0.036	0.076	
t=-11	0.027	0.027	0.038	0.038	0.044	0.041	0.049	0.056	0.045	0.049	0.078	0.067

Section 5: Back of the envelope calculations:

Having established a systematic relationship between the Ginis of different accounting periods in after-tax household income in Israel, it is worth to investigate the implications of those findings for developing an intuitive evaluation of the connection between the magnitude of the Gini and the accounting period.

The empirical evidence points out that we can safely use equation (3) because the additional and complicated terms of equation (2) do not affect the relationship between the Gini of the longer accounting period to the Ginis of its components. Since it is clear that any trend will affect the relationship, let us assume no trend in the data: that is $G_t = G$, $\Gamma_{jt} = \Gamma$, for j,t=1,…,T, and $a_i = 1/n$ for all i.[10] Inserting those assumptions into equation (3), it is expected that the lower the values for Γ_{ij} and Γ_{ji}, the larger the decrease in the Gini index of inequality over several periods of time. The magnitude of the (Gini) correlations between incomes in different time periods is thus a key factor in determining the impact of the length of the accounting period on measured inequality. Moreover, inserting the assumptions into (2) one gets:

$$G_0^2 - \frac{1}{n} G_0 G \sum_{t=1}^{T} D_{t0} = G_t^2 [\frac{1+(n-1)\Gamma}{n}] \ . \qquad (4)$$

Note that it is not straightforward to assess a priori what values the Gini correlations will take. The length of the various periods taken into account may affect the value of the Gini correlations in several ways. First, it is reasonable to assume that with observations corresponding to longer periods of time, there will be less noise in the data, so that the longer the period the larger the denominator will be in the expression of the correlation (as would the variance under less noisy data), and therefore the absolute value of the Gini correlations between longer periods will be higher. On the other hand, the same reduction in noise may also increase the absolute value of the numerator, since less noise will tend to increase the covariance between income in one period and the rank of the individual in the distribution of income in the other period. Assuming also that the overall distribution is exchangeable with the distribution of every sub-period, leads us to the following relationship:

$$\frac{G_0}{G_t} \cong \sqrt{\frac{1+(n-1)\Gamma}{n}} \qquad (5)$$

where G_o, G_t are the overall and the sub-period Ginis, respectively. Equation 5 gives us a rough approximation to the effect of the accounting period on the Gini. For example,

[10] It is reasonable to also require that Γ_{ij} will decline as a function of (i-j). However, the data did not show a large magnitude of decline and it is not clear how to model that. As a first approximation it seems reasonable to ignore this fact.

assuming that the Gini correlation is $\Gamma = 0.9$, then dividing the accounting period to two periods should reduce the Gini by 2.6 percentage points. On the other hand, reducing the accounting period to a third of its length, increases the Gini by 3.5 percentage points.

Section 6: Sensitivity Analysis

The relationship between the Ginis of the monthly incomes and the quarterly and yearly incomes were stable over a long period of time. The aim of this section is to try to find out whether these relationships hold also for alternative definitions of income. Instead of looking at after tax income per household we change the distribution to be after tax income per equivalent adult, according to the equivalence scale used in Israel.[11] This section brings the result of extremely different stories with respect to the relationship between Pearson and Spearman correlation coefficients that were found with the same definition of income but with a different unit of analysis.

[11] The marginal weights for each additional person are: the first is 1.25; the second is 0.75, the third 0.65, the fourth and fifth 0.55, the sixth and seventh 0.5, the eighth 0.45, every additional person from the ninth on is 0.40.

Table 11: The Components of Gini by Monthly After-Tax Income per Equivalent Adult (Source: Household Expenditure Survey, 1999)

	Gini indices of inequality (G_i) and income shares (a_i)				
	Quarter	t=0	t=-1	t=-2	
Gini Coefficient	0.36520	0.37336	0.37386	0.37020	
St. Error	(0.0056)	(0.0072)	(0.0072)	(0.0065)	
Income share	1	0.3363	0.3329	0.3307	
	Gini Correlations matrix (Γ_{ij})				
i/j	Quarter	t=0	t=-1	t=-2	
Quarter	1	0.9739	0.9819	0.9803	
t=0	0.9772	1	0.9372	0.9264	
t=-1	0.9831	0.9353	1	0.9528	
t=-2	0.9811	0.9311	0.9534	1	
	G_O	G_O^2	$G_O\Sigma a_i D_{iO} G_i$	$a_i^2 G_i^2$	$\Sigma\Sigma a_i a_j G_i G_j \Gamma_{ij}$
Quarter	0.3652	0.1334	0.0002	0.0463	0.0869

Table 11 replicates Table 1, this time with income defined as income per equivalent adult, and each household is given, in addition to the sampling weight, the weight of the number of equivalent adults in household.[12] As can be seen the results are almost identical to Table 1 with $G_O\Sigma a_i D_{iO} G_i$ being close to zero, so that equation (3) holds in the data. The other components also yield results that are similar to the results of Table 1.

Table 12: Differences in Gini Correlations (Γ_{ij}-Γ_{ji})

i/j	Quarter	t=0	t=-1
t=0	0.0033		
t=-1	0.0013	-0.0019	
t=-2	0.0008	0.0046	0.0006

Table 12 presents the differences in Gini correlations indicating that the differences are negligible, while Table 13 presents the test statistics, showing that we can reject the hypothesis that the Gini correlations differ from each other, and therefore equation (3) can be safely used to analyze the relationship between monthly and quarterly Ginis.

[12] This assumption is required if one wants the average income per equivalent adult not to be sensitive to the share of income that is held by households of different size.

Table 13: Test Statistics

i/j	Quarter	t=0	t=-1
t=0	1.4644		
t=-1	1.2784	-0.4099	
t=-2	0.6760	0.5837	0.1619

Table 14 presents the Pearson and Spearman correlation coefficients. Again, it shows that the Pearson correlation coefficients are much lower than the Spearman correlation coefficients with the former being a declining function of the time difference between the periods while the latter are less sensitive to the difference in the time gap between the periods. It is interesting to note that the difference between them can reach a magnitude of 0.5 as can be seen from the entry of t= -1 and t= -2. As before, the Gini correlations are closer to the Spearman correlation coefficients than to Pearson's, indicating that we should expect the Pearson correlation coefficients to decline in a more dramatic fashion when one lengthens the accounting period.

Table 14: Pearson and Spearman Correlations
Pearson in the lower left triangle, Spearman in the upper right triangle.

	Quarter	t=0	t=-1	t=-2
Quarter		0.973	0.980	0.979
t=0	0.849		0.935	0.928
t=-1	0.844	0.667		0.953
t=-2	0.820	0.538	0.463	

Table 15 presents the difference between Spearman and Pearson correlation coefficients which is even larger than detected before. The maximum value is almost 0.5; that can clearly lead one to different conclusions about the strength of the correlation between the variables.[13] All in all we can conclude that changing the income from household income to equivalent adult income does not affect our analysis.

[13] See Yitzhaki and Wodon (2004) for analysis of the implication of the magnitude of the correlation on the measurement of mobility.

Table 15: Difference Between Spearman and Pearson Correlations

Difference = $Spearman_{ji}$ - $Pearson_{ij}$

	Quarter	t=0	t=-1
t=0	0.124		
t=-1	0.136	0.268	
t=-2	0.159	0.390	0.490

Table 16 replicates Table 11, this time for the year of 1979. As we see, the average monthly Gini is 0.3531, which is about 7.5 percent higher than the yearly Gini, consistent with the findings for after tax household incomes (7 percent). The term $G_O \Sigma a_i D_{iO} G$ is equal to zero leading us to the conclusion that equation (3) gives a perfect approximation to the decomposition.

Table 16: The Components of Gini by Monthly After-Tax Income per Equivalent Adult

(Source: Household Expenditure Survey, 1979-80)

	Gini indices of inequality (G_i) and income shares (a_i)												
	Annual	t=0	t=-1	t=-2	t=-3	t=-4	t=-5	t=-6	t=-7	t=-8	t=-9	t=-10	t=-11
Gini Index	0.3286	0.3369	0.3416	0.3413	0.3404	0.3433	0.3471	0.3498	0.3549	0.3558	0.3671	0.3685	0.3908
St. Error	(0.0072)	(0.0075)	(0.0079)	(0.0074)	(0.0073)	(0.0073)	(0.0077)	(0.0074)	(0.0074)	(0.0074)	(0.0082)	(0.0076)	(0.0071)
Income share	1	0.0825	0.0813	0.0812	0.0811	0.0820	0.0820	0.0820	0.0816	0.0817	0.0817	0.0835	0.0995
	Gini Correlations matrix (Γ_{ij})												
i/j	Annual	t=0	t=-1	t=-2	t=-3	t=-4	t=-5	t=-6	t=-7	t=-8	t=-9	t=-10	t=-11
Annual	1	0.939	0.935	0.943	0.947	0.951	0.947	0.947	0.943	0.941	0.931	0.912	0.864
t=0	0.932	1	0.933	0.919	0.905	0.881	0.880	0.870	0.860	0.844	0.827	0.815	0.778
t=-1	0.933	0.923	1	0.931	0.909	0.896	0.880	0.862	0.850	0.848	0.821	0.806	0.749
t=-2	0.941	0.912	0.932	1	0.931	0.905	0.899	0.872	0.864	0.856	0.832	0.810	0.753
t=-3	0.943	0.899	0.900	0.930	1	0.926	0.914	0.898	0.874	0.863	0.836	0.823	0.752
t=-4	0.945	0.881	0.897	0.902	0.927	1	0.938	0.909	0.880	0.876	0.848	0.831	0.764
t=-5	0.947	0.865	0.870	0.888	0.900	0.927	1	0.927	0.899	0.883	0.855	0.829	0.759
t=-6	0.947	0.860	0.851	0.868	0.890	0.896	0.917	1	0.924	0.905	0.879	0.845	0.762
t=-7	0.942	0.848	0.842	0.855	0.861	0.871	0.901	0.916	1	0.926	0.890	0.862	0.768
t=-8	0.939	0.838	0.855	0.853	0.855	0.862	0.879	0.899	0.923	1	0.913	0.879	0.765
t=-9	0.932	0.828	0.833	0.834	0.831	0.838	0.847	0.881	0.893	0.907	1	0.904	0.791
t=-10	0.913	0.807	0.802	0.800	0.809	0.816	0.828	0.846	0.860	0.876	0.909	1	0.803
t=-11	0.858	0.769	0.755	0.756	0.750	0.768	0.762	0.775	0.775	0.783	0.808	0.842	1
	G_O		G_O^2		$G_O \Sigma a_i D_{iO} G_i$		$a_i^2 G_i^2$		$\Sigma\Sigma a_i a_j G_i G_j \Gamma_{ij}$				
Annual	0.3286		0.1079		-0.0003		0.0105		0.0980				

The relationship between the other terms are similar to the relationship found in earlier tables so we could conclude the sensitivity analysis as showing an extra ordinary stable relationship.

Table 17: Differences in Gini Correlations (Γ_{ij}-Γ_{ji})

i/j	Annual	t=0	t=-1	t=-2	t=-3	t=-4	t=-5	t=-6	t=-7	t=-8	t=-9	t=-10
t=0	-0.007											
t=-1	-0.002	-0.009										
t=-2	-0.002	-0.007	0.001									
t=-3	-0.004	-0.005	-0.009	-0.001								
t=-4	-0.007	0.000	0.001	-0.003	0.001							
t=-5	0.000	-0.015	-0.010	-0.011	-0.014	-0.011						
t=-6	0.000	-0.011	-0.011	-0.003	-0.008	-0.012	-0.010					
t=-7	-0.001	-0.012	-0.007	-0.008	-0.013	-0.008	0.002	-0.008				
t=-8	-0.003	-0.006	0.007	-0.003	-0.008	-0.014	-0.004	-0.006	-0.003			
t=-9	0.000	0.000	0.012	0.003	-0.005	-0.010	-0.008	0.002	0.003	-0.005		
t=-10	0.001	-0.008	-0.003	-0.010	-0.014	-0.015	-0.002	0.001	-0.003	-0.002	0.004	
t=-11	-0.005	-0.009	0.006	0.002	-0.002	0.005	0.004	0.013	0.007	0.018	0.018	0.039

Table 17 presents the difference in Gini correlations where the maximum value detected is 0.04 while almost all others are close to zero.

Table 18: Statistical Tests

i/j	Annual	t=0	t=-1	t=-2	t=-3	t=-4	t=-5	t=-6	t=-7	t=-8	t=-9	t=-10
t=0	-2.454											
t=-1	-0.872	-1.945										
t=-2	-0.916	-1.604	0.315									
t=-3	-2.750	-0.837	-0.884	-0.191								
t=-4	-1.792	0.004	0.142	-0.352	0.274							
t=-5	-0.034	-2.517	-0.904	-1.616	-2.210	-1.825						
t=-6	0.067	-1.833	-0.923	-0.452	-1.091	-1.450	-1.284					
t=-7	-0.561	-1.646	-0.599	-1.192	-2.032	-0.816	0.329	-1.802				
t=-8	-1.571	-0.908	1.397	-0.533	-1.360	-1.675	-0.643	-1.011	-0.565			
t=-9	0.173	0.022	0.795	0.212	-0.400	-0.825	-0.594	0.198	0.305	-0.553		
t=-10	0.314	-1.351	-0.325	-1.509	-1.456	-1.656	-0.202	0.088	-0.372	-0.355	0.339	
t=-11	-1.642	-1.167	0.502	0.325	-0.291	0.626	0.423	1.734	0.839	2.753	1.362	5.548

Table 18 shows that the majority of test statistics are insignificant with only one t-statistic of a value above 3.

Table 19: Pearson and Spearman Correlations

Pearson in the lower left triangle, Spearman in the upper right triangle.

	Annual	t=0	t=-1	t=-2	t=-3	t=-4	t=-5	t=-6	t=-7	t=-8	t=-9	t=-10	t=-11
Annual		0.933	0.926	0.937	0.942	0.947	0.943	0.947	0.935	0.933	0.923	0.899	0.848
t=0	0.941		0.928	0.916	0.902	0.883	0.870	0.865	0.848	0.836	0.821	0.799	0.755
t=-1	0.937	0.930		0.932	0.907	0.896	0.873	0.856	0.841	0.836	0.815	0.786	0.734
t=-2	0.944	0.915	0.925		0.934	0.909	0.895	0.871	0.850	0.845	0.824	0.790	0.737
t=-3	0.944	0.904	0.896	0.918		0.930	0.909	0.893	0.862	0.850	0.829	0.807	0.739
t=-4	0.948	0.888	0.894	0.897	0.919		0.938	0.908	0.875	0.866	0.841	0.816	0.755
t=-5	0.930	0.860	0.861	0.873	0.886	0.899		0.929	0.896	0.878	0.854	0.823	0.754
t=-6	0.943	0.871	0.859	0.872	0.894	0.897	0.886		0.925	0.909	0.882	0.844	0.767
t=-7	0.946	0.868	0.856	0.879	0.872	0.884	0.884	0.906		0.929	0.892	0.856	0.768
t=-8	0.944	0.856	0.861	0.868	0.872	0.879	0.866	0.892	0.912		0.918	0.875	0.771
t=-9	0.917	0.825	0.824	0.833	0.830	0.839	0.821	0.856	0.870	0.883		0.913	0.803
t=-10	0.906	0.813	0.808	0.811	0.815	0.823	0.805	0.834	0.851	0.866	0.862		0.824
t=-11	0.849	0.777	0.751	0.755	0.746	0.766	0.740	0.760	0.767	0.766	0.767	0.789	

Tables 19 and 20 show respectively, the Pearson and Spearman correlations and the differences between them. The large differences detected between them in earlier analysis almost disappear with the maximum difference being less than 0.04. Moreover, a large number of differences are negative which means that the Pearson correlation coefficients are greater than the Spearman correlation coefficients. Therefore, the conclusion that Spearman correlation coefficients are greater than the appropriate Pearson correlation coefficients does not hold. One cannot conclude that since the Gini correlations are close to the Spearman correlation coefficients, and the Spearman correlation coefficients are greater than the Pearson correlation coefficients, then we should expect the Gini to decline at a slower rate than the coefficient of variation as a result of an increase in the accounting period.

Table 20: Difference Between Spearman and Pearson Correlations

Difference = $Spearman_{ji}$ - $Pearson_{ij}$

	Annual	t=0	t=-1	t=-2	t=-3	t=-4	t=-5	t=-6	t=-7	t=-8	t=-9	t=-10
t=0	-0.008											
t=-1	-0.011	-0.003										
t=-2	-0.007	0.001	0.007									
t=-3	-0.002	-0.001	0.011	0.016								
t=-4	-0.001	-0.005	0.002	0.012	0.011							
t=-5	0.013	0.010	0.011	0.022	0.023	0.039						
t=-6	0.003	-0.006	-0.003	0.000	-0.001	0.011	0.043					
t=-7	-0.011	-0.020	-0.016	-0.028	-0.010	-0.009	0.012	0.019				
t=-8	-0.010	-0.020	-0.025	-0.023	-0.022	-0.014	0.012	0.016	0.017			
t=-9	0.005	-0.003	-0.009	-0.009	-0.001	0.002	0.033	0.026	0.021	0.036		
t=-10	-0.008	-0.014	-0.022	-0.021	-0.008	-0.007	0.017	0.009	0.005	0.009	0.051	
t=-11	-0.001	-0.023	-0.017	-0.019	-0.007	-0.012	0.014	0.007	0.001	0.005	0.036	0.035

Conclusions:

In this paper, we have investigated the empirical relationship between the length of the accounting period and the magnitude of the Gini coefficient. We have found that for household after tax incomes in Israel, the Gini index of inequality can be decomposed into the contribution of monthly components by a formula that is identical to the formula used to decompose the coefficient of variation. This conclusion holds also for inequality of income per equivalent adult. It is also found that inequality for monthly income is about seven percent higher than inequality for yearly income, while inequality for quarterly income is almost two percent lower than inequality for monthly income.

We also found that the Gini correlation coefficients between two periods tend to be equal to each other and in general they tend to be closer in magnitude to Spearman correlation coefficients than to Pearson correlation coefficients. In some cases it is found that the differences between Spearman and Pearson correlation coefficients can be large, hence, it seems that it is worth to report both correlation coefficients in order to get an idea about the associations between random variables. To illustrate the importance of this conclusion note that Behrman and Taubman (1989) estimated that inter-generational correlation of parental income and offsprings is 0.58 when ten years of earnings are used. The findings of this paper do not exclude the possibility that had they also estimated Spearman correlation coefficient, they would have found a coefficient that can be between 0.2 to 0.9. Clearly, such a finding could have changed our evaluation of inter-generational mobility.

The conclusions seem to be data and country specific. Additional research on different data sets is needed in order to get a clearer picture on the sensitivity of inequality measurement to the length of the accounting period.

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