Inequality decomposition by factor component: a new approach illustrated on the Taiwanese case

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Key Words: Inequality, Income distribution, Inequality decomposition by factor components, Taiwan.

Classification JEL: D3, D63, O15, O53

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This version: November 1999

* I would like to thank François Bourguignon, Denis Fougères, François Gardes, Sylviane Guillaumont-Jeanneney, Marc Gurgand and Sylvie Démurger as well as participants at seminars in CERDI and CREST for helpful comments.

1. Introduction

The rise in inequality observed in most industrialised countries and specifically in the United States has lead to rising concern for distributional issues since the beginning of the 90s (Atkinson, 1997; Atkinson and Bourguignon, 1998; Kanbur, 1999; Kanbur and Lustig, 1999). Parallel to the development of theoretical and empirical works, methodological issues have recently been raised, leading to the elaboration of new tools for the analysis of the sources of changes in the distribution of income. Inequality decomposition methods have been developed in two main directions, one initiated by Juhn, Murphy and Pierce's (1993) work on decomposition methods based on micro-simulation techniques, the other in the line of DiNardo, Fortin and Lemieux's (1996) paper, based on non-parametric weighting techniques. However, both methods are focussed on inequality decomposition by population sub-groups and bring little perspective about the decomposition of inequality by factor component[1].

The question of the relative importance of various income sources in the level, and in the distribution, of total income is nonetheless a central aspect of the analysis of observed changes in income inequality. Indeed, inequality decomposition by factor component allow for an evaluation of the specific impact of a given income source (capital income for example) on total income inequality. Moreover, it gives valuable information on the evaluation of the impact on the distribution of total household income of changes in household structure as well as changes in labour force participation behaviours[2]. This feature has been at the core of various empirical studies of the rise in income inequality in the US, which point out changes in household structure and participation behaviours as central factors[3]. Usual factor decomposition of income inequality is however restricted to some specific inequality index and suffers from a number of limitations highlighted by Shorrocks (1982) theorem.

In a recent work, Burtless (1999) studies the impact of changes in the correlation between spouses' income on US household inequality using an alternative methodology. We show in this paper that the method succinctly and intuitively exposed by Burtless on a specific empirical framework can be systematised into a general decomposition methodology allowing to overcome a number of drawbacks inherent to the use of usual decomposition procedures. This method, which we will call *rank-correlation method*, does not rely on any parametrical assumptions and provides easily interpretable results as is shown by the illustration driven on the Taiwanese case provided by the second part of this paper.

After a decrease in inequality since the beginning of the 50s, Taiwan has experienced a worsening of household income distribution since the end of the 70s. Bourguignon, Fournier and Gurgand (1999a) show that an important part of the observed rise in inequality can be imputed to changes occurring within the structure of households. Several other studies also insist on the unequalizing effect due to rising endogamy in terms of education in the assortative mating of spouses in Taiwan (Fields and Leary, 1997; Tsai, 1994). However, usual procedures fail to provide a specific evaluation for the magnitude of this phenomenon. The second part of this paper proposes a new study of this issue through the implementation of the rank-correlation method on Taiwanese data over the 1979-94 period.

The paper is organised as follows. Section 2 discusses theoretical results concerning usual methods for inequality decomposition by factor components and proposes a generalisation of the alternative approach initiated by Burtless (1999). Section 3 applies this method to income distribution changes in Taiwan over the 1979-94 period. Section 4 concludes and discusses further methodological developments to be derived from this approach.

2. À new approach to inequality decomposition by factor component

2.1 *Usual decomposition procedures: Shorrocks' theorem*

Usual inequality decomposition by factor components can be formalised as follows. Let Y be total income derived from N distinct income sources:

(1) $$Y = \sum_{k=1}^{N} Y_k$$

and let I be an inequality index. Decomposing inequality by factor components consists in deriving a set of N contributions $(S_k)_{k=1 \ldots N}$ such that:

a) S_k is a function of the distribution of the *kth* income source - written $\{Y_k\}$ - and of its relative share in total income (π_k).

b) $$I(Y) = \sum_{k=1}^{N} S_k(\{Y_k\}, \pi_k)$$

S_k thus represents the *kth* income source contribution to observed inequality in total income Y.

Two main approaches can be found in the literature. The first includes works based on the decomposition of the variance of income and, following Fei, Ranis and Kuo (1978), on the decomposition of the Gini coefficient. This approach tries to define easy to apply and intuitively appealing decompositions but remains based on *ad hoc* formulations. The second approach follows Shorrocks (1982) formalisation of inequality decomposition by factor components through the definition of a set of axioms leading to a general decomposition procedure.

Variance decomposition

The usual decomposition[4] of the variance allows for relatively simple factor decomposition for the variance as well as most inequality measures derived from the variance (especially the coefficient of variation). Indeed, the variance of total income Y can be written as the following function of the standard errors of sources (σ_k) and of the covariance between sources (Cov):

$$\sigma^2(Y) = \sum_{k=1}^{N} \sigma_k^2 + \sum_{k \neq j} \sum_{j=1}^{N} Cov(Y_j, Y_k)$$

(2)

$$= \sum_{k=1}^{N} Cov(Y, Y_k)$$

which directly provides the S_k contributions for the variance of total income, $S_k = Cov(Y, Y_k)$.

This decomposition directly applies to the square of the coefficient of variation as follows:

$$CV^2(Y) = \frac{\sigma^2(Y)}{\mu^2}$$

(3)

$$= \sum_{k=1}^{N} \frac{Cov(Y, Y_k)}{\mu^2}$$

which provides an evaluation of the contribution of various income sources to overall observed inequality. Moreover, it should be noted here that the relative contribution of income sources is the same for the variance or the coefficient of variation, since in both cases we have:

(4) $$s_k = \frac{S_k(Y_k)}{I(Y)} = \frac{Cov(Y, Y_k)}{\sigma^2(Y)}$$

Gini coefficient decomposition

Following Fei, Ranis and Kuo (1978), Pyatt, Chen and Fei (1980) proposed a decomposition procedure for the Gini coefficient as a weighted sum of « pseudo-Gini » terms ($\tilde{G}_k$), using the relative share of sources in total income as weights (Φ_k), so that:

(5) $$G(Y) = \sum_{k=1}^{N} \phi_k \tilde{G}_k \quad , where \quad \phi_k = \frac{\sum_i Y_k^i}{\sum_i Y^i}$$

« Pseudo Gini » coefficient $\tilde{G}_k$ is computed as a Gini coefficient over the *kth* income source (Y_k), individuals (or any other unit) being ranked in terms of *total* income (Y) and not in terms of the *kth* income source.

Pyatt, Chen and Fei (1980) also show that « pseudo Gini » coefficients can be written as a function of individuals ranks in terms of total income (ρ) and of the *kth* income source (ρ_k) as follows:

(6) $$\tilde{G}_k(Y, Y_k) = G(Y_k) \frac{Cov(Y_k, \rho)}{Cov(Y_k, \rho_k)}$$

The Gini coefficient can thus be written as a weighted sum of Gini coefficients computed (in the usual way) on various income sources as follows:

(7) $$G(Y) = \sum_{k=1}^{N} \phi_k \frac{Cov(Y_k, \rho)}{Cov(Y_k, \rho_k)} G(Y_k)$$

Equation (7) allows for a decomposition of the Gini coefficient into the sum of terms depending solely on the distribution of a specific income source and its correlation with total income. Here, as for the decomposition of the variance of total income, each contribution can be positive as well as negative. A negative sign refers to a negative correlation between the income source and the rank with respect to total income, which means that the income source lowers total income inequality (this will be the case for example for transfers).

Shorrocks' theorem: an impossibility theorem

Shorrocks (1982) proposes a formalisation for inequality decomposition by factor component. He shows that the decomposition procedures exposed above rely on strong *ad hoc* implicit hypotheses concerning the allocation of interaction effects between income sources to the contributions of each income source. Indeed, Shorrocks shows that there are an infinite number of possible decomposition rules for any given inequality index depending on the hypothesis made and emphasises the necessity to impose further decomposition properties. Proposing a series of simple straightforward axioms, Shorrocks proves the following theorem:

Theorem: *Under six relatively intuitive hypotheses concerning the decomposition rule (detailed appendix 1), for any given inequality measure (I), decomposing inequality by factor component leads to:*

(8) $$\frac{S_k(Y_k, Y)}{I(Y)} = \frac{Cov(Y_k, Y)}{Var(Y)} = s_k$$

This result is extremely strong since, under Shorrocks' six hypotheses, the inequality share imputable to the *kth* income source (s_k) does not depend on the choice of the inequality index. The following decomposition rule (8) indeed gives, for any inequality index, a relative contribution for the *kth* income source equal to that obtained *naturally* from the decomposition of the variance.

The main drawback of the approach defined by Shorrocks (1982) is indeed the independence of the relative contributions of income sources with respect to the choice of the inequality index[5]. When trying to explain an observed change in inequality, this property also implies that the contribution of any income source only depends on total income inequality (and not on the inequality measured on the marginal distribution of this specific source). Shorrocks (1982) theorem is thus more an impossibility result than a practical analysis framework, impossibility linked to the necessity to deal with existing interrelations between income sources. Indeed, when trying to decompose inequality by factor components, three factors are at stake: the inequality observed within each income source, the relative shares of income sources in total income and the existing correlation between income sources. Decomposing inequality by factor components as defined above thus implies choosing an allocation procedure for the inequality (or equality) induced by the correlation between income sources. Shorrocks (1982) shows that there are an infinity of such allocation procedures and that imposing enough constraints on the decomposition to overcome the indetermination leads to a very restrictive decomposition framework. The only acceptable decomposition procedure is indeed restricted to the *natural* decomposition of one of the less attractive inequality index: the square of the coefficient of variation.

2.2 *An alternative approach: the rank correlation method*

As mentioned above, the evolution of the overall distribution of total income comes from the combination of three phenomena: the evolution of the relative share of various sources in total income, the evolution of the marginal distribution of each income source and the modification of the correlation between income sources. The difficulty arising when trying to disentangle these three dimensions resides in the impossibility to consider a variation of the marginal distribution of a specific income source keeping constant both the marginal distribution of other sources and the correlation between sources.

Burtless (1999), in an empirical study of income inequality in the US, proposed an alternative approach which opens new perspectives in inequality decomposition by factor components. His approach relies on a simple idea: a shift from *statistical correlation* to *rank correlation*. We argue here that this approach, presented succinctly and intuitively by Burtless on a specific case study, can be systematised and allow for the isolation of the specific effects of changes in the marginal distribution of income sources as well as that of changes in the correlation structure between sources.

This method consists in affecting to individuals (or households) observed at date t a counter-factual income component keeping either marginal distributions or rank-correlation between sources fixed. Two types of simulation can thus be computed in order to isolate the two effects.

Modification of the marginal distribution of income source y_i keeping marginal distributions of other sources as well as the correlation between sources unchanged

Any individual[6] *(a)* observed at date t at rank n_1, in the income scale of income source y_1, can be imputed the income component y'^{n1}_1 of the individual *(c)* corresponding to the same rank n_1 in y_1 but observed at date t'. The simulation derived from this reallocation keeps the distribution of other income sources observed in t unchanged and provides a counter-factual marginal distribution for income source y_1 which corresponds to that observed at date t'. Comparing inequality measured on the counter-factual total income to observed total income inequality in t thus provides the specific effect of changes in the distribution of income source y_1 keeping rank-correlation between sources unchanged. This simulation of course alters the statistical correlation between income sources but preserves the rank-correlation.[7]

Modification of the correlation between sources, keeping marginal distribution of income sources unchanged

Symmetrically, the rank-correlation structure of income sources observed at date t' can be applied to the population observed at date t through the reallocation between individuals of observed values for various income sources. Let individual *(a)* be of rank n_1 and n_2 in y_1 and y_2 at date t[8]. Let n_1' be the rank in y_1 of individual *(d)* observed at date t' in the same rank

n_2 in y_2. Individual *(a)* can then be imputed income $y_1^{n_1'}$ observed for individual *(b)* at date t in rank n_1' in y_1. This simulation only results in the reallocation between individuals of incomes observed at a given date t. The counter-factual distribution obtained thus preserves the marginal distributions y_1 and y_2, whereas the simulated rank-correlation structure between sources is that observed at date t'[9].

Recapitulation

These two simulation procedures are relatively simple to implement and are based on totally non-parametric computations since they only use the rank structure of various income sources and simply affect various observed incomes differently among individuals.

Tables 1 and 2 provide a recapitulation of simulations discussed above and a simple numerical example provided in appendix 2 gives an illustration of the method. For simplification purposes total income y is supposed to be derived from only two income sources y_1 and y_2 ($y = y_1 + y_2$).

For any individual (a) observed in t:

- at ranks n_1 and n_2 with respect to y_1 and y_2,
- with observed income $y = y_{n1} + y_{n2}$,

the following individuals (b) to (d) can be defined as follows:

Table 1: Definitions

	Date t					Date t'			
Indiv.	***Income y_1***	***Rank / y_1***	***Income y_2***	***Rank / y_2***	***Indiv.***	***Income y_1***	***Rank / y_1***	***Income y_2***	***Rank / y_2***
(*a*)	y_{n1}	n_1	y_{n2}	n_2	**(*c*)**	n_1	y'_{n1}	l_2	y_{l2}
(*b*)	y_{m1}	m_1	y_{m2}	m_2	**(*d*)**	m_1	y'_{m1}	n_2	y'_{n2}
Mean income	μ_1				**Mean income**		μ'_1		

Following the notation described table 1, the two simulation procedures discussed above can be summarised as follows for any individual *(a)*:

Table 2: Rank-correlation method, recapitulation

Simulations for individual (a)	y_1	y_2
Observed income sources for individual (a) at date t	y_{n1}	y_{n2}
Modification of the marginal distribution of y_1 keeping marginal distribution of y_2 and correlation structure unchanged	$\tilde{y}_{n1} = y'_{n1} \cdot \frac{\mu_1}{\mu'_1}$ y'_{n1} is observed income for individual **(*c*)** of rank n_1 in y_1	y_{n2} (observed)
Modification of the correlation structure keeping marginal distributions of income sources unchanged	$\tilde{y}_{n1} = y_{m1}$ y_{m1} is observed income in *t* for individual **(*b*)** of rank m_1 in y_1, m_1 being the rank in y_1 at date *t'* for individual **(*d*)** of rank n_2 in y_2	y_{n2} (observed)

It should finally be noted that decompositions presented here from date *t* to date *t'* can as well be computed symmetrically from date *t'* to date *t*. As for any decomposition analysis of the "*shift-share*" type, both paths *a priori* lead to different results and confronting computation results provides a robustness test for measured effects. Moreover, income sources can be changed in table 2 leading two the evaluation of changes in the marginal distribution of y_2[10].

The method presented here cannot strictly speaking solve the question of the sharing rule for the correlation between sources pointed out by Shorrocks (1982) since statistical correlation are modified by simulations. It however provides a way to decompose observed changes in the distribution of income by factor component into factors, which are easy to interpret. Moreover, this method presents the major advantage to allow for a distinction between changes in the correlation between income sources and changes in the marginal distribution of sources. Indeed, usual decomposition procedures only provide a global evaluation of the two aspects subject to some *ad hoc* sharing rule for the correlation effect between sources.

A second major advantage of this method is that it allows for a decomposition of the whole distribution of income and is not based on a specific inequality index. It thus allows for the decomposition of Lorenz curves as well as any synthetic measure, every different index providing different results depending on its specific sensitivity properties.

Finally, this method does not rely on any modelisation or parametrical assumption. It can nonetheless easily be combined with various parameterisations in order to deal with related issues such as changes in labour force participation or changes in household size.

Two main limits can however be noted here. First, the approach proposed can only provide a decomposition of changes in income distribution and does not give any static decomposition at a specific point in time as usual methods do. Second, the decomposition results do not provide an exact decomposition of inequality changes and the sum of the various effects is not *a priori* equal to the total observed evolution[11].

3. Taiwan 1979-94

This section provides an illustration of the rank-correlation method to the evolution of household income distribution in Taiwan over the 1979-94 period.

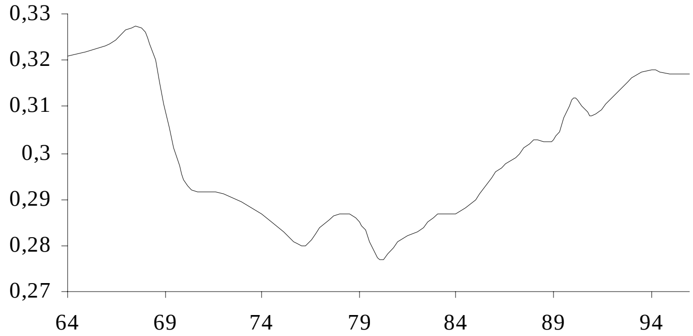
3.1. *Evolution of household income distribution in Taiwan (1979-94)*

Taiwan appears as a counter-example to the Kuznets (1955) hypothesis predicting an inverted U-shape relationship between economic development and inequality. Indeed, since the settlement of the Republic of China in Taiwan in 1949, this country has experienced an exemplary growth process not only without increasing inequality but even with decreasing income disparities up to the beginning of the 80s. This evolution has made Taiwan in the 90s a newly industrialised country with high growth rates and inequality levels comparable or below western countries standards.

As shown figure 1, household income distribution has however become more unequal since the end of the 70s, which lead to a series of discussions on what as been called, following Hung (1996), the “great U-turn”[12].

Figure 1: Inequality of household income (1964-96)

(Gini)



Source: DGBAS (1996).

Inversely, the distribution of individual wages in Taiwan shows a continuous decrease in inequality since the end of the 70s. The 80s and 90s thus appear as a period of divergence between a decrease in inequality at the individual level and an increase in inequality in total household income. Using a micro-simulation based decomposition method, Bourguignon, Fournier and Gurgand (1999a) show that these trends come from the combination of various compensating forces of strong magnitude. Indeed, a strong unequalising force, at the individual as well as at the household level, is shown to be caused by the rise in returns to education, whereas the expansion of education in the population has had the opposite effect. This study shows that most of the observed divergence between the evolution in individual and household income inequality is to be imputed to changes in household structure. Other recent studies of the Taiwanese income inequality also emphasise changes in household structure as a key factor in explaining the observed rise in household income inequality since the end of the 70s (Chu, 1997; Fields and Leary, 1997; Schultz, 1997; Tsai, 1994). Usual analyses of the decomposition of inequality changes as well as recent methodological developments however fail to provide any further study of this phenomenon. The rank-correlation method exposed above thus appears here as a valuable complementary tool for the identification of the sources of income inequality changes in Taiwan.

3.2. *Data*

Fully comparable micro-data from household survey are only available over the period 1979-94; we will thus restrict the analysis to the observed rise in household income over this period.

The empirical analysis is based on a series of household surveys conducted annually since 1979 on samples composed of 16 400 households by the Taiwanese government (*Directorate-General of Budget Accounting and Statistics*, DGBAS). Household surveys are in fact available since 1976, but the quality of the data prior to 1979 as well as various adjustments made on the size of the sample lead us to restrict the analysis to the period 1979 onwards. The surveys are intended to provide information on the living standards of Taiwanese inhabitants and actually provide valuable, rich and reliable data[13]. A new sample is draws every year; it thus provides a set of repeated cross section and not a panel.

It should finally be noted that all income sources considered in the following empirical work are evaluated as income *per adult equivalent*, using the square root of the total number of household members as the equivalence scale.

3.3. *Changes in the structure of household income by type of household members*

The joint evolution of household structure, participation behaviour and remuneration structure, which have been taking place in Taiwan over the period studied has led to major changes in the structure of primary household income structure by type of household members. This evolution is illustrated by the following table.

Tableau 3: Structure of primary household income by type of household members (1979-94)
(%)

	Share in total income		**Share in wage income**	
	1979	*1994*	*1979*	*1994*
Wages				
Household head	49.5	50.1	69.2	65.7
Spouses	6.3	12.3	8.8	16.1
Children	8.0	5.1	11.2	6.7
Other members	7.7	8.7	10.8	11.4
Income from independent activities[14]	28.5	23.9	-	-

It should first be noted that the share in total household wage income provided by household heads has substantially declined, whereas that of spouses increased quite strongly. Moreover, increasing scolarisation at higher education levels as well as the decline in fertility led to a strong decrease in the relative share of children in total household income.

Changes in household structure also comes from changes in the correlation between the characteristics of household members, and especially of spouses (Tsai, 1994). At the same time, changes in participation behaviour especially strong for spouses and children has also led to a modification of the correlation between individual incomes within households[15].

The following empirical work thus proposes an implementation of the rank-correlation method to total household income considered as the sum of individual income provided by various household members and income derived from independent activities.

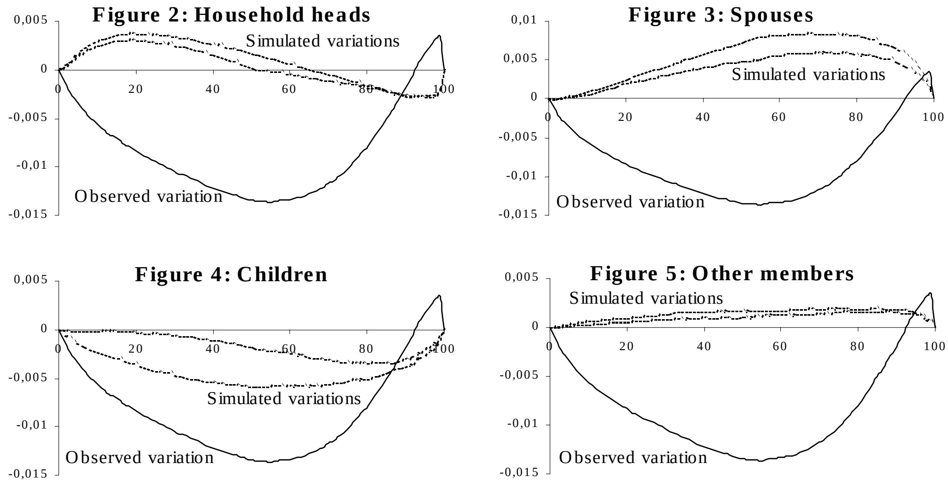
Changes in the marginal distribution of individual incomes of different household members

The first decomposition exercise proposed in the rank-correlation decomposition method described above consists in isolating the specific impact on total household income of observed changes in the distribution of a specific income source. Figures 2 to 5 represent the specific effect of changes in the marginal distribution of the wage income of each type of household member. The effects are measured keeping the marginal distribution of other income sources as well as rank-correlation between the source studied and its complementary to total household income unchanged. Figures show the simulated variation in Lorenz curves. A negative curve on the whole income scale corresponds to an increase in inequality (*i.e.* the dominance of Lorenz curves) induced by the simulation. Finally, as mentioned above, simulations are computed from initial to final date as well as from final to initial date and the confrontation of both results can be viewed as a robustness test.

The plain curve represents the observed change in primary household income distribution as measured by Lorenz curves. Its negative sign up to the very top of the distribution reflects the observed rise in inequality described above using the Gini coefficient[16].

These figures show that changes in the marginal distribution of all types of members except heads and children have had an equalising effect on overall household income distribution. The effect observed for household heads is ambiguous, since curves cross the horizontal axis, which corresponds to a cross in Lorenz curves. However, the curves being first above and then below the horizontal axis, the effect is equalising at the bottom of the distribution and unequalising at the top. Lorenz dominance at the bottom of the distribution implies that the measured effect will be equalising for inequality indexes most sensitive to changes at the bottom of the distribution. As noted above, the distribution of individual income has become more equal over the period studied, which naturally entails that the specific effect of changes in the marginal distribution of most types of household members has had an equalising effect on total household income distribution.

Figures 2 to 5: Variation in the marginal distribution of wage income for different household members
Variation in Lorenz curves – Household primary income (1979-94)



Note: Abscissas represent the cumulative share of households, ranked by increasing total income. The equivalence scale used is the square root of the total number of household members. The number of household members weights households.

Results concerning children of household heads however call for further discussion. Indeed, the study of income distribution changes within this class also shows a decrease in inequality, however, figure 4 shows a non-ambiguous rise in inequality for total household income distribution induced by this evolution. This result comes from the rapid widening of scolarisation at higher levels, which led children to enter the labour market much later. This evolution both comes from a strong concern and political efforts from the Taiwanese government[17] as well as from a loosening of the budget constraint for poorer households, induced by the high growth rates observed all over the period. As lower income households tend to have more opportunities to keep their children scolarised for a longer period, their relative income in the whole population suffers all the more that children represent a much larger part of total household income at the bottom of the distribution of household income. Applying the observed distribution of children income in 1994 to the population observed in 1979 thus induces a net loss coming from the increase in the share of non-working children, which is concentrated at the bottom of the distribution.

Changes in the correlation between the income of household members

The second type of exercise proposed by the rank-decomposition method consists in measuring the specific impact of changes in the correlation between income sources, keeping marginal distribution of sources unchanged. Figures 6 to 9 show the specific impact of changes in rank-correlation between the income of each type of household member and its complementary to total household income.

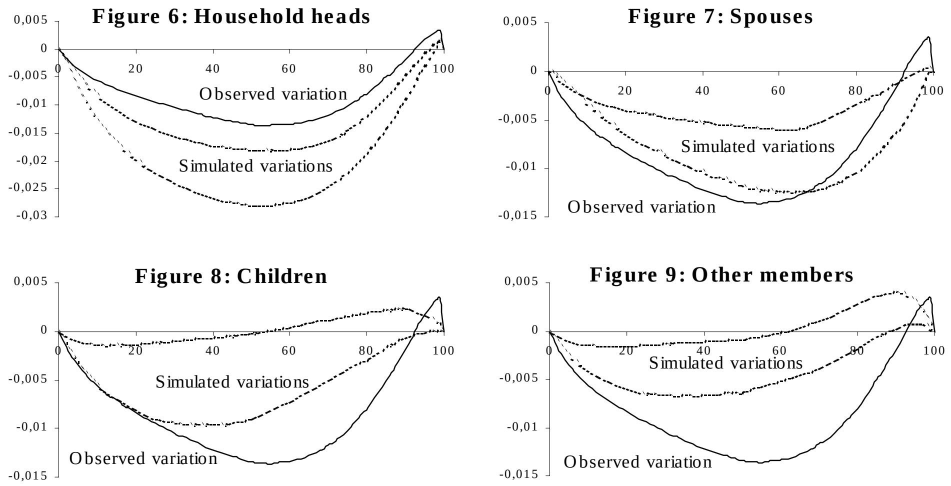
Figures 6 and 7 show non-ambiguous unequalising effects of strong magnitude induced by changes in rank-correlation for household heads and spouses. These results can be related to two main simultaneous factors: rising female participation and rising endogamy in the assortative mating of spouses especially in relation with education and age[18] [Tsai (1994), Fields and Leary (1997)]. More specifically, concerning the rise in female labour supply, Bourguignon, Fournier and Gurgand (1999a) show a sizeable unequalising effect induced both by entries into the labour force at the top of the distribution of household income and exits at the bottom. This evolution can be explained for one part by the rise in the participation of more educated women, which are strongly concentrated within richer household. For the other part, exits from the labour force of women belonging to poorer households can be explained as the result of a loosening of the budget constraint induced by the rapid rise in average income during the Taiwanese development process.

The specific impact of changes in the correlation between children income and total household income shown figure 8 seems to go in the same direction even though the effect depends on the sensitivity properties of the inequality index when computations are made upon the 1979 reference year. The central mechanism, as before, concerns the lengthening of scolarisation, which has had a stronger impact on children belonging to poorer households and which has been allowed by the overall rise in income. It is thus clear that the decrease in labour force participation has increased, everything else being equal, the correlation between household income and children income, since more children have no income in poorer households. Figure 8 isolates the effect keeping marginal distributions (and thus participation to the labour market) unchanged and shows, at least for simulations based on the 1994 data, a sizeable unequalising effect.

Finally, figure 9 shows a very similar trend (although non-robust) concerning the other members of the household. This evolution should be linked to the decrease in the age of retirement over the period studied.

Indeed, also as a result of rising overall income, older members of poorer households (parents or relatives) tend to have had more liberty in the choice of their desired retirement age. This of course implies a rise in the correlation between this income source and total household income.

Figures 6 to 9: Variation in the correlation between the income of household members and total household income
Variation in Lorenz curves – Household primary income (1979-94)



Note: Abscissas represent the cumulative share of households, ranked by increasing total income. The equivalence scale used is the square root of the total number of household members. The number of household members weights households.

Summary of results

The rank-decomposition method presented in this paper allows for a decomposition of the whole income distribution upon which standard inequality indexes can be straightforwardly computed. Between 1979 and 1994, the Gini coefficient for household primary income by adult equivalent has risen from 0.271 to 0.288. Table 4 summarises this 0.017 point rise in terms of Gini coefficient using simulation results for the various effects presented figures 2 to 9.

The three main results discussed above are clearly visible on this table: *i)* changes in the marginal distribution of spouses' income have been equalising, *ii)* changes in the marginal distribution of children's income has increased overall inequality, and *iii)* changes in the correlation between the income of various household members has been the strongest unequalising force. This last result highlights the central role played on household income inequality by changes occurring within the structure of households and particularly in the assortative mating of spouses. Indeed, the magnitude of the effect measured for household heads and spouses is comparable or larger than the total observed change in inequality over the 1979-94 period.

Table 4: Summary of results using Gini coefficient (1979-94)

	Gini Coefficient	
	*1979 Population**	*1994 Population**
Observed variation	0.017	
Variation due to marginal distributions		
Household head	-0.001	-0.002
Spouses	-0.007	-0.011
Children	0.009	0.003
Other members	-0.002	-0.003
Variation due to correlation changes		
Household head	0.038	0.025
Spouses	0.016	0.008
Children	0.012	0.000
Other members	0.008	0.000

Notes: (*) Population upon which the simulation has been computed. The equivalence scale used is the square root of the total number of household members. The number of household members weights households.
A negative number indicates a decrease in inequality. Different signs in the two columns correspond to a non-robust effect (for the Gini coefficient).

4. Conclusion

This article shows that the decomposition procedure briefly initiated by Burtless (1999) can actually be systematised and provides a new general method for decomposing income inequality changes by factor components. The method, based on the concept of rank-correlation, provides a useful tool answering some major drawbacks inherent to usual decomposition procedures.

Indeed, this method allows for a decomposition of the whole income distribution and is thus not restricted to the use of a specific inequality index. It thus provides a decomposition procedure for observed changes in Lorenz curves as well as any synthetic inequality measure and the results obtained depend on the specific sensitivity properties of chosen indexes at various points of the distribution, which is not the case for decomposition methods following Shorrocks (1982) approach.

Moreover, the decomposition procedure proposed here provides useful answers to the central question raised by Shorrocks (1982) about the sharing of the role played by the correlation between sources among income sources. The rank-decomposition method indeed allows for a further decomposition step in distinguishing the specific impact of changes in the correlation between sources from that of changes in the marginal distribution of sources, whereas usual decomposition procedures only provide a global evaluation based on a given sharing rule for correlation factors, which is inevitably partial.

The implementation of the method to the Taiwan case illustrates the type of results it can provide and allows for a better understanding of some major factors behind the rise in household income inequality over the 1979-94 period. Indeed, three main sources of inequality change can be derived from this decomposition procedure: *i)* a sizeable equalising effect coming from changes in the distribution of spouses' (marginal) income distribution, *ii)* a notable unequalising effect induced by the decline in labour force participation of children following the rise in scolarisation, and *iii)* a major unequalising effect (which magnitude is much stronger than the first two) coming from changes in the correlation between various household members' income. We finally argue here, that this last point is to be linked with changes in the assortative mating of spouses and especially with rising endogamy in terms of education and age induced by profound sociological changes leading to a shift from traditional Chinese marriages to a freer choice of bride or groom.

Results for the Taiwanese case plead more generally in favour of the use and development of methods dealing with inequality decomposition by factor components. Indeed, the method proposed here is complementary to recent developments in inequality decomposition through micro-simulation techniques (Juhn, Murphy and Pierce, 1993; Bourguignon and Martinez, 1997; Bourguignon, Fournier and Gurgand, 1999a)[19]. These methods only provide a general evaluation of the impact of changes in population and household structure on income distribution and can not isolate the specific factors highlighted here. Combining both approaches within a common framework would certainly be of great interest for the understanding of the major sources of inequality changes.

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Appendix 1 — Conditions proposed by Shorrocks (1982)

Shorrocks (1982) proposes the following six conditions for the decomposition of total income Y by N factor components:

- *Condition 1:* I is a continuous and symmetric inequality measure.

- *Condition 2 (Continuity and symmetry):*

  a) Each term $S_{k,k=1...N}$ is continuous in Y_k.

  b) Terms $S_{k,k=1...N}$ are invariant to any permutation of income sources.

- *Condition 3 (Independence of the level of disaggregation):* Each component $S_{k,k=1...N}$ is independent of how other factors $Y_{j \neq k}$ are grouped.

- *Condition 4 (Consistence of the decomposition):* $S_{k,k=1...N}$ is invariant to any permutation of individuals[1].

- *Condition 5 (Normalisation):* The contribution of an evenly distributed income source is *0*.

- *Condition 6 (Symmetry):* For any two factor components decomposition (Y_1 and Y_2), if Y_1 can be derived from Y_2 by a simple permutation then $S_1 = S_2$.

[1] The term “individual” is to be understood here as any unit(individual, household, family, etc.).

Appendix 2 — Example of implementation of the rank-decomposition method

Distributions of income sources at dates t and t':

Date t					Date t'				
Income y_1	***Rank / y_1***	***Income y_2***	***Rank / y_2***	***$y = y_1+y_2$***	***Income y_1***	***Rank / y_1***	***Income y_2***	***Rank / y_2***	***$y = y_1+y_2$***
10	2	5	1	15	15	3	10	1	25
5	1	15	2	20	13	2	15	2	28
25	3	30	3	55	12	1	25	3	37

Modification of marginal distribution of income source y_2 keeping marginal distributions of other income sources and correlation between sources unchanged:

Income $\tilde{y}_1$	***Rank / $\tilde{y}_1$***	***Income y_2***	***Rank / y_2***	***$\tilde{y} = \tilde{y}_1 + y'_{\cdot 2}$***
13	2	5	1	**18**
12	1	15	2	**27**
15	3	30	3	**45**

Modification of correlation between sources keeping marginal distributions of sources unchanged:

Income $\tilde{y}_1$	***Rank / $\tilde{y}_1$***	***Income y_2***	***Rank / y_2***	***$\tilde{y} = \tilde{y}_1 + y'_{\cdot 2}$***
25	***3***	5	1	**30**
10	***2***	15	2	**25**
5	***1***	30	3	**35**

Notes

[1] Developments of the micro-simulation methodology proposed by Bourguignon, Fournier and Gurgand (1999) however take into account some aspects of the question, modelling specifically occupational choice behaviours and income functions in various occupations.

[2] Total household can indeed be considered as the sum of individual incomes of various household members.

[3] See for example Burtless (1999), Gottschalk and Danziger (1993) and Lerman (1996).

[4] Shorrocks (1982) calls it the "natural decomposition".

[5] This drawback has led various authors to relax some of Shorrocks (1982) axioms. See for example Chantreuil and Trannoy (1997).

[6] The term “individual” is to be understood here as any unit (individual, household, family, etc.).

[7] Counter-factual incomes imputed have to be weighted by the share of the mean of the income source at dates *t* and *t’* in order to preserve the overall mean income observed in *t*.

[8] The generalisation to three sources and more is straightforward.

[9] Here again, the statistical correlation simulated will not *a priori* correspond to that of date *t’*.

[10] The effect measured for the modification of the correlation between income sources is however unchanged whatever income source the simulation is based upon.

[11] It would be possible to provide an exact decomposition by computing various simulations based on the previous estimation results. This type of decomposition would however lead to an important number of possible combinations concerning the order in which simulation may be computed, each combination giving *a priori* a different result.

[12] This result, illustrated here on gross total household income is robust to the use of various equivalence scales (Fournier, 1999, pp.222-224).

[13] For a discussion on the reliability of the data, see for example Deaton and Paxson (1993).

[14] Income derived from independent activities of household members (agricultural or not) can not be affected to any particular household member in the data.

[15] For a detailed study of changes in female labour supply in Taiwan over the 1979-94 period, see Bourguignon, Fournier and Gurgand (1999b).

[16] Fournier (1999) shows that most inequality indicators show a rise in inequality.

[17] Free and compulsory education has been lengthened from 6 to 9 years in 1968 and a law has recently been passed to implement a further increase to 12 years by 2001.

[18] The correlation coefficient between the education of spouses rose from 0.66 to 0.72 between 1979 and 1994. Between the age of spouses, a rise from 0.84 to 0,90 has been taking place over the same period.

[19] See Fournier (1999) for a detailed presentation of the methodology.