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Educational presorting and occupational segregation

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Abstract

This article concentrates on the measurement of both occupational and educational segregation between men and women of the Dutch labour force. The majority of studies which have been conducted in this area are rather one-sided, concentrating on occupational segregation only. However, occupational segregation can be split into three components. The first component concerns presorting as a consequence of the different educational choices made by boys and girls. The second component concerns postsorting (given their educational status), as a result of the differing occupational choices and opportunities for promotion between men and women during their careers. If men and women with the same educational background are directed towards different occupations, then postsorting may add to the occupational segregation which was already induced by the earlier educational segregation. This kind of postsorting increases the gap between occupational and educational segregation. The third component, which we refer to as reintegration, is also a kind of postsorting but narrowing the gap between occupational and educational segregation. This occurs when men with a 'male type' of education and women with a 'female type' of education come together in one occupation. Given that educational segregation of the labour force is fixed in the short term, reintegration is the only effective, but probably difficult affirmative action program to reduce occupational segregation in the short term. More usual programs are ineffective and can even be counterproductive. A more detailed insight into these three components is relevant when choosing the policy instruments needed to achieve equal employment opportunities for men and women. The paper shows that from 1979 until

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1993/1994 educational segregation increased, but occupational segregation decreased. Partly, this is explained by increased reintegration, but the main cause of these developments is a clear increase in presorting in education. © 1999 Elsevier Science B.V. All rights reserved.

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1. Introduction

In the economic analysis of men and women's respective positions in the labour market much attention has been paid to the measurement of *occupational* segregation (hereafter abbreviated as OS), i.e., the extent to which women's jobs differ from those of men. Although the number of studies measuring segregation is quite large, most of them limit themselves to the measurement of OS only (see for example Beller, 1982; Albelda, 1986; Karmel and Maclachlan, 1988; King, 1992; Watts and Rich, 1993; Boisso, 1994). At best, OS is combined with educational statistics in a rather loose way. A systematic treatment connecting educational segregation (henceforth ES) and OS is lacking. Therefore, the current state of affairs is that we have a good understanding of the incidence of OS, but know much less about the way it is brought about. Differing educational choices act as constraints on the future occupational choice. As well as this educational induced segregation, there is also the segregation which occurs when boys and girls with the same educational background end up in different occupations. Finally, how important is reintegration, i.e., men and women with differing educational backgrounds ending up in the same jobs? These are the questions which this article attempts to answer.

We define *presorting* as the extent to which different educational distributions of boys and girls give rise to or cause different occupational distributions of men and women.¹ The phenomenon of presorting will be stronger, the stronger the link between education and occupation. If there is no connection between education and occupation, measuring ES in order to explain OS would be of no use at all. ES and OS would be independent of each other, and no presorting would take place.

Postsorting is defined as the extent to which, *given* the ES, men and women end up in different occupations. Suppose that there is no ES which implies that presorting cannot take place. OS or postsorting can still arise if men and women with the same educational background end up in different occupations. This will increase OS between the sexes, adding to that expected when presorting takes

¹ Alternatively, one may wish to define presorting as the extent to which boys and girls choose different educational careers, *irrespective* of its effects on the occupational segregation later on. However, this is just ES proper.

place. There might, however, be a compensating tendency in the transition from school to the labour market. Women with a ‘female’ educational background might find jobs in the same occupations as men who followed a typical ‘male’ type of education. This is a kind of negative postsorting, but we prefer to call this phenomenon *reintegration*. The relationship between ES and OS therefore possibly consists of both diverging and converging tendencies towards an otherwise equal occupational distribution. This implies that, given the degree of ES (which can be considered as fixed in the short term), there are still possibilities to decrease overall OS. A very effective way to do this is to provide employers with incentives to hire female (male) workers with an educational background which is predominantly female (male) in nature for typical male (female) type jobs. For instance, engineers on trains and trams and bus drivers are traditionally male jobs. Workers for these jobs are usually recruited from those engaged in education which is male in nature, for example, lower technical vocational education. Since very few women are enrolled in this type of education, one can reduce OS in this segment of the labour market (and elsewhere) by recruiting and training women from female types of education (i.e., types of education in which the share of women exceeds the share of females in the total labour force) for these jobs. However, an affirmative action program (AAP) which aims at recruiting more women with a lower technical vocational education for the transport jobs does not reduce OS, since it forces employers elsewhere in the labour market to take less women with this educational background for other technical jobs.

With this in mind, we can distinguish between two types of AAP’s, one ineffective and one effective in the short term. Ineffective AAP’s are those which do not take into account the fact that the ES of the labour force cannot be changed immediately. These programs require more women in male dominated jobs, even if the women who possess the skills required for the job are short in supply. Effective AAP’s however are those which fully acknowledge the ES, but which try to neutralize its impact on OS, e.g., by offering special training programs to members of the underrepresented group in order to enable them to get access to these jobs.² Examples of both are given in Section 4.

The structure of the article is as follows. Section 2 contains an analysis of the well-known Duncan and Duncan segregation or dissimilarity index along with the first empirical results. In Section 3 we continue the analysis by linking OS to ES in order to disentangle the different components which are responsible for the gap. In Section 4 empirical results, based on Dutch labour force survey’s from 1979 until 1993/1994, are provided concerning the components of the segregation process which were distinguished in the analytical section. Conclusions can be found in Section 5.

² If the cause of segregation is discrimination, this strategy is of no use. Here though we implicitly assume that the cause is more in line with human capital theory.

2. The measurement of segregation

Most analyses of OS are related to the so-called Duncan and Duncan (1955) dissimilarity index:

$$D = \frac{1}{2} \sum_{j=1}^m \left| \frac{F_j}{F} - \frac{M_j}{M} \right| \tag{1}$$

where F_j (M_j) represents the number of women (men) working in job j , and F (M) the total number of women (men) working.³ This index measures the fraction of women (or men) that have to change their job in order to equalise female and male occupational distributions. As has been argued by Karmel and Maclachlan (1988), Watts (1992) and others, this index has two disadvantages. Firstly, it measures the number of job changes required to achieve an equal distribution as a fraction of the total number of women or men, while it would be more appropriate to relate the number of changes needed to the total number of workers, male or female. Secondly, and more importantly, the changes that are generally required in order to achieve an equal distribution will change the occupational distribution. The Duncan and Duncan index therefore not only measures the required changes which will equalise the female distribution with the male distribution, but furthermore these changes affect the size of the different occupational categories, that is, the occupational distribution itself.

To acquire a more appropriate index, as introduced by Siegers (1979) in his Appendix and Karmel and Maclachlan (1988), imagine that both men and women change jobs in such a way that the occupational distribution is unaffected, and that these changes are related to the total number of workers. Denoting the number of people working in job j by T_j (with $T_j = F_j + M_j$), the target number of female workers in job j equals $F_j T_j / T$ and for the male $M_j T_j / T$. Here, we consider the number of workers in each job (the occupational distribution T_j) as given. Therefore, the adjusted segregation index equals:

$$S = \frac{1}{2} \sum_{j=1}^m \left| \frac{F_j}{T} - \frac{F_j T_j}{T^2} \right| + \frac{1}{2} \sum_{j=1}^m \left| \frac{M_j}{T} - \frac{M_j T_j}{T^2} \right| = \frac{F \cdot M}{T^2} \sum_{j=1}^m \left| \frac{F_j}{F} - \frac{M_j}{M} \right| \tag{2}$$

³ Note that the segregation indexes discussed in this paper only concern men and women who are working. Segregation between employed, unemployed and people who are not participating is not analyzed. If an AAP is launched in a segment of the labour market with a high unemployment rate, it may force employers to recruit more unemployed persons of the underrepresented group with the requisite educational skills in which case the AAP is effective. By treating the unemployed or non-participating as an occupational category, these groups could be integrated in the analyses.

Defining $\theta \equiv F \cdot M \cdot / T \cdot^2$ gives $S = 2\theta D$, a relationship that will be used throughout this paper.^{4,5}

In order to investigate the link between ES and OS, data⁶ about the number of people in education i and occupation j are used. These numbers are denoted by T_{ij} , which can be divided into women and men with $T_{ij} = F_{ij} + M_{ij}$. Again, totals are denoted by a dot. The educational totals are $T_i = F_i + M_i$, the occupational totals are $T_j = F_j + M_j$ and the grand totals are $T = F + M$.

By analogy with (2) the index for ES can be expressed as:

$$ES = \theta \sum_{i=1}^n \left| \frac{F_i}{F \cdot} - \frac{M_i}{M \cdot} \right| = \sum_{i=1}^n ES_i \quad (3)$$

with

$$ES_i = \theta \left| \frac{F_i}{F \cdot} - \frac{M_i}{M \cdot} \right| \quad (4)$$

as the i th component of the ES and

$$ES_i^{\text{rel}} = \theta \left| \frac{F_i}{F \cdot} - \frac{M_i}{M \cdot} \right| \frac{T_i}{T_i} \quad (5)$$

as the *relative* i th component of the ES. The factor T_i/T_i is used here as a weight to counterbalance the relative importance of education i so that different educations become mutually comparable. If the number of people enrolled in i is small, the expression between the absolute operators is also small. Without the weight factor (as in (4)), we would get a very small outcome, even if ES in i is assumed to be complete. Analogously, the OS can be defined as:

$$OS = \theta \sum_{j=1}^m \left| \frac{F_j}{F \cdot} - \frac{M_j}{M \cdot} \right| = \sum_{j=1}^m OS_j \quad (6)$$

⁴ See Borghans and Groot (1999) for the complete derivation of (2).

⁵ Blackburn et al. (1995) show that these indices can be expressed as functions of only four basic numbers: the number of male and female workers in male and female occupations, in which (fe)male occupations are defined as occupations in which the fraction (fe)males is above the average for the whole labour market. The further analyses presented in this paper do however not allow for this simplification.

⁶ Data are taken from the Dutch labour force surveys of Statistics Netherlands (CBS). For 1979–1985 this is the so-called Arbeids–Krachten–Telling (AKT) covering approximately 2.5% of the labour force in 1979, 1983 and 1985 and 5% in 1981. For 1993/1994 the survey is called Enquête Beroeps–Bevolking (EBB). This survey covers approximately 1% yearly. For this reason a double year has been used, making coverage comparable with the former survey.

Table 1

ES and OS on the Dutch labour market in 1979 to 1993/1994 (source AKT, CBS)^a

	ES (%)	OS (%)
1979	17.9	24.8
1981	18.5	25.2
1983	19.9	26.0
1985	20.8	25.9
1993/1994	21.6	23.8

^aThe segregation indices are based on 49 occupational segments of the ROA occupational classification and 54 educational types (see Table 4).

and total segregation (TS) as:

$$TS = \theta \sum_{i=1}^n \sum_{j=1}^m \left| \frac{F_{ij}}{F} - \frac{M_{ij}}{M} \right| = \sum_{i=1}^n \sum_{j=1}^m TS_{ij} \quad (7)$$

Table 1 shows ES and OS for 1979 through to 1993/1994.⁷ The figures indicate that OS is larger than ES. Groot (1990) suggested that ES can be regarded as the presorting of men and women by the educational system. Up until 1985 the trend seems indeed to suggest that the increase in segregation is mainly due to the increase in ES. However, while OS grew only gradually during the 1979–1983 period and decreased thereafter, ES continued to increase.⁸ A main reason for this increased ES is that many older people with only a primary education (including both men and women), leave the labour market through retirement or disability, and are replaced by young people who have at least an intermediate or higher vocational training, where ES is more likely to occur.⁹ However, this process only explains half of the increase in ES. For the purpose of our studies, it is important to note that the gap between OS and ES diminishes over time, and also that both are able to move independently, even in opposite directions. The figures therefore do not necessarily indicate a causal relationship between ES and OS. It is possible for ES to increase, and at the same time see the probability of women and men ending up in different occupations becoming less.

Table 2 provides segregation indices for 1985 in which educations or occupations are classified differently.¹⁰ If the two-digit ISCED educational classification

⁷ Of course, the degree of OS (and ES) is influenced by the degree of disaggregation. If we define each job position as a separate occupation, then OS is complete. Thus in general the higher the degree of disaggregation, the higher the segregation indexes.

⁸ Similar trends can be found when using the Duncan and Duncan index. The increase in educational segregation is not therefore explained by an increase in female labour participation.

⁹ However, in the past women had lower chances to enroll in higher education. In so far as older women only have access to lower level jobs, there was also a link between ES and OS in the past.

¹⁰ Since information about sectors of industry is not available for 1993/1994, data of 1995 have been used for these calculations.

Table 2

ES, OS and sectoral segregation (SS) of men and women in 1985

ES based on 54 educational types	20.8
ES based on 5 educational levels	4.2
ES based on 14 educational subjects	18.7
OS based on 49 occupational categories	25.9
SS based on 16 sectors of industry	15.0

is replaced by a classification where only the educational *level* is taken into account, ES largely disappears. Thus, employed women do not have lower educational levels than employed men. With a classification of educational subjects only, the segregation level remains almost the same. ES can therefore be identified as mainly subject segregation. Furthermore Table 2 shows that the assertion that ES *inevitably* passes on to OS through presorting is premature. In the final row of the table the occupational classification is replaced by a classification of 16 sectors of industry in which people work. The segregation over sectors is much lower than OS, and this particular example shows that it is impossible to regard ES a priori as presorting for segregation (whether occupational or sectoral) in the labour market. Of course, the link between type of education and occupation differs from the link between the type of education and sector of industry. For example, those who receive a secretarial training will probably become secretaries working in all sectors of industry. But other types of education, for instance in hotel and catering, may exhibit a tight connection with a particular sector of industry. In the former ES will not pass on to sectoral segregation, while in the latter it will. Table 2 shows only that ES does not *necessarily* pass on to either OS or sectoral segregation. To investigate the relationship between ES and OS it is necessary to relate ES to OS analytically, and to investigate this relationship empirically. Section 3 provides the analytical relationships, while Section 4 provides the empirical results.

3. The relation between educational and occupational segregation

As a starting point for the analysis of the relationship between ES and OS, imagine that students from one type of education are distributed over all occupations in proportion to their educational sex ratios. This distribution which is induced by ES equals:

$$F_{ij}^{\text{educ}} = \frac{F_i}{T_i} T_{ij} \quad (8)$$

and

$$M_{ij}^{\text{educ}} = \frac{M_{i.}}{T_{i.}} T_{ij} = T_{ij} - F_{ij}^{\text{educ}} \tag{9}$$

In a distribution which obeys (8) and (9), so that for all (i,j) $F_{ij} = F_{ij}^{\text{educ}}$, only presorting occurs and no postsorting takes place. In such a world of ES passing on fully to OS, the chance of a randomly selected woman ending up in (i,j) , given the number of workers T_{ij} , depends only on the fraction of women within education i . In what we term as the ‘ideal’ or equal distribution, (fe)male workers are distributed according to their overall ratio:

$$F_{ij}^{\text{equal}} = \frac{F_{i.}}{T_{i.}} T_{ij} \tag{10}$$

and

$$M_{ij}^{\text{equal}} = \frac{M_{i.}}{T_{i.}} T_{ij} = T_{ij} - F_{ij}^{\text{equal}} \tag{11}$$

In this equal distribution, neither pre- or postsorting occurs, nor is there any ES or OS. The notion of the equal distribution is important as an archimedean point in the measurement of segregation. The pre- and postsorting means that the actual F_{ij} and M_{ij} differ from their equal counterparts. The equal distribution is that which can be expected in a world where there are no sex-related differences in educational choices or occupational opportunities. Given the number of workers in (i,j) , the chance of a randomly selected woman ending up in (i,j) would in this case only depend on the overall female employment rate.

Given (10) and using the same procedure as in (2):

$$\sum_{i=1}^n \sum_{j=1}^m \left| \frac{F_{ij}}{T_{i.}} - \frac{F_{ij}^{\text{equal}}}{T_{i.}} \right| = \theta \sum_{i=1}^n \sum_{j=1}^m \left| \frac{F_{ij}}{F_{i.}} - \frac{M_{ij}}{M_{i.}} \right| \tag{12}$$

equals TS as defined by (7). TS thus measures the ‘distance’ between the actual and the equal distribution, in both the educational and the occupational dimension. Given the educational distribution of men and women, the additional segregation (AS), that is the first component of postsorting during the transition from school to the labour market, is calculated by:

$$AS_i = \sum_{j=1}^m \left| \frac{F_{ij}}{T_{i.}} - \frac{F_{ij}^{\text{educ}}}{T_{i.}} \right| = \sum_{j=1}^m \left| \frac{F_{ij}}{T_{i.}} - \frac{\frac{F_{i.}}{T_{i.}} T_{ij}}{T_{i.}} \right| \tag{13}$$

Relatively this index equals:

$$AS_i^{\text{rel}} = AS_i \frac{T}{T_i} \quad (14)$$

Based on this index per education type, an index of the total AS can be constructed:

$$AS = \sum_{i=1}^n AS_i \quad (15)$$

AS is an index which correctly expresses the first component of postsorting, with complete presorting as the baseline. With complete presorting, AS equals zero.¹¹ It measures the distance between the actual distribution and the distribution which we would expect with complete presorting due to ES. What we have said so far seems to suggest that OS, i.e., the difference between the occupational distribution of women and men, can be decomposed into ES and postsorting. However, it does not necessarily hold that $OS = ES + AS$. The non-negativity of all three segregation indexes implies that $OS \geq ES$. However, if we replace occupational by sectoral segregation as in the final row of Table 2, we see that this cannot be true since sectoral segregation is smaller than ES. The reason why it is not possible to simply add AS to the ES is twofold. Firstly, the whole amount of ES does not necessarily pass fully on to OS. The extent to which it does depends on the tightness of the link between the (mainly vocational) skills learned during formal schooling and the specific skills demanded for particular jobs. Secondly, this addition—if carried out correctly—relates to TS (see Eqs. (7) and (12)), rather than OS.

3.1. Increasing and decreasing segregation

In order to disentangle the relationships¹² between the different measures of segregation, Table 3 shows the six possible positions of F_{ij}^{equal} , F_{ij}^{educ} , and F_{ij} (see also Table 6). The first row gives all the situations where women are underrepresented when compared to the equal distribution (F_{ij} is to the left of F_{ij}^{equal}), while in the second row women are overrepresented (F_{ij} is to the right of F_{ij}^{equal}). By using (8) and (10):

$$F_{ij}^{\text{educ}} > F_{ij}^{\text{equal}} \Leftrightarrow \frac{F_i}{T_i} > \frac{F}{T} \quad (16)$$

¹¹ Incomplete presorting requires some postsorting in the sense that some women and men with the same educational background are allocated differently over the various occupations.

¹² For a more comprehensive treatment of disentangling segregation into its components, see Borghans and Groot (1999).

Table 3

The six possible orderings of F_{ij}^{educ} , F_{ij}^{equal} and F_{ij}

	$F_{ij}^{\text{educ}} < \min\{F_{ij}, F_{ij}^{\text{equal}}\}$	$F_{ij}^{\text{educ}} < \max\{F_{ij}, F_{ij}^{\text{equal}}\}$ $F_{ij}^{\text{educ}} > \min\{F_{ij}, F_{ij}^{\text{equal}}\}$	$F_{ij}^{\text{educ}} > \max\{F_{ij}, F_{ij}^{\text{equal}}\}$
$F_{ij} < F_{ij}^{\text{equal}}$	$\begin{cases} I_{ij} = 0 \\ D_{ij} = \frac{F_{ij} - F_{ij}^{\text{educ}}}{T} \end{cases}$	$\begin{cases} I_{ij} = \frac{F_{ij}^{\text{educ}} - F_{ij}}{T} \\ D_{ij} = 0 \end{cases}$	$\begin{cases} I_{ij} = \frac{F_{ij}^{\text{equal}} - F_{ij}}{T} \\ D_{ij} = \frac{F_{ij}^{\text{educ}} - F_{ij}^{\text{equal}}}{T} \end{cases}$
$F_{ij} > F_{ij}^{\text{equal}}$	$\begin{cases} I_{ij} = \frac{F_{ij} - F_{ij}^{\text{equal}}}{T} \\ D_{ij} = \frac{F_{ij}^{\text{equal}} - F_{ij}^{\text{educ}}}{T} \end{cases}$	$\begin{cases} I_{ij} = \frac{F_{ij} - F_{ij}^{\text{educ}}}{T} \\ D_{ij} = 0 \end{cases}$	$\begin{cases} I_{ij} = 0 \\ D_{ij} = \frac{F_{ij}^{\text{educ}} - F_{ij}}{T} \end{cases}$

F_{ij}^{educ} can thus only be to the right of F_{ij}^{equal} if education i is of a ‘female type’, that is if the educational ratio between women and men within i is higher than the overall ratio of (employed) women and men. If F_{ij}^{educ} is to the right of F_{ij} , then women are underrepresented compared to what would have been expected given the educational distribution of men and women.

The distance F_{ij}^{equal} to F_{ij}^{educ} represents the effect of presorting. Postsorting as measured by AS relates to the distance F_{ij}^{educ} to F_{ij} , and this can be an increase or a decrease: both are movements away from the distribution induced by ES, but if the movement is towards the equal distribution it counts as a decrease while any movement away from it represents an increase. Table 3 and the formulas below show the contributions that the increases I_{ij} and decreases D_{ij} make to AS.

By summing all the increases

$$I = \frac{1}{T} \sum_{i=1}^n \sum_{j=1}^m I_{ij} \tag{17}$$

and all the decreases

$$D = \frac{1}{T} \sum_{i=1}^n \sum_{j=1}^m D_{ij} \tag{18}$$

a direct consequence of these definitions is that:

$$AS = I + D \tag{19}$$

and

$$TS = ES + I - D \tag{20}$$

This implies that AS sums all the deviations, both increases and decreases, from what is expected given the educational distribution of men and women (that is, if only presorting and no postsorting occurs). This means that if a number of women with a particular education type are more than proportionally represented in one job (as in the first two sections of the second row of Table 3), it must also necessarily be the case that there are other jobs where women are less than proportionally represented (as in the last two sections of the first row).^{13,14} This ‘equality’ or law of communicating vessels implies that for TS to be larger than ES it must be the case that sometimes the actual situation (F_{ij}) and the situation induced by ES (F_{ij}^{educ}) are on opposite sides of the equal distribution. This is shown in the third section of the first row and the first section of the second row. This will mean that relatively more women with a particular education type will be working within a certain occupation compared with the overall ratio, while traditionally, this education type is more readily associated with men, or vice versa. We shall call such a combination of education and occupation an *inverse segregation situation*. The predicate ‘inverse’ is used here since the actual distribution is the opposite to what one would expect given presorting (ES). In Section 4 we see that this is not a rare phenomenon: it occurs in 30.2% of all cases (see Table 6).

3.2. Total versus occupational segregation

Eqs. (19) and (20) relates TS, ES and AS to each other. Nevertheless, the question of how these relate to OS is still unanswered. OS is always less than or equal to TS, and this can be derived as follows:

$$\begin{aligned}
 \text{OS} &= \theta \sum_{j=1}^m \left| \frac{F_{.j}}{F_{.}} - \frac{M_{.j}}{M_{.}} \right| = \theta \sum_{j=1}^m \left| \sum_{i=1}^n \left(\frac{F_{ij}}{F_{.}} - \frac{M_{ij}}{M_{.}} \right) \right| \\
 &= \sum_{j=1}^m \left| \sum_{i=1}^n \left(\frac{F_{ij}}{T_{.}} - \frac{F_{ij}^{\text{equal}}}{T_{.}} \right) \right| \leq \theta \sum_{j=1}^m \sum_{i=1}^n \left| \frac{F_{ij}}{F_{.}} - \frac{M_{ij}}{M_{.}} \right| \\
 &= \sum_{j=1}^m \sum_{i=1}^n \left| \frac{F_{ij}}{T_{.}} - \frac{F_{ij}^{\text{equal}}}{T_{.}} \right| = \text{TS} \tag{21}
 \end{aligned}$$

OS is strictly smaller because in any occupation where there are relatively more women than men, male workers can be employed from education groups where

¹³ To understand (20), note that ES measures the unequal distribution of men and women over educations, irrespective of the occupations they have chosen. As a consequence, the actual ES of the labour force and the ES of a distribution where $F_{ij} = F_{ij}^{\text{educ}}$ as with (8) and (9) are equal.

¹⁴ As already mentioned in note 3, this neglects the existence of unemployment.

there are relatively more men. To calculate the extent of this effect on each occupation, TS has to be divided into a male and a female component:

$$TSF_j = \theta \sum_{i=1}^n \max \left\{ \left(\frac{F_{ij}}{F_{\cdot}} - \frac{M_{ij}}{M_{\cdot}} \right), 0 \right\} = \sum_{i=1}^n \max \left\{ \left(\frac{F_{ij}}{T_{\cdot}} - \frac{F_{ij}^{equal}}{T_{\cdot}} \right), 0 \right\} \quad (22)$$

and

$$TSM_j = \theta \sum_{i=1}^n \max \left\{ \left(\frac{M_{ij}}{M_{\cdot}} - \frac{F_{ij}}{F_{\cdot}} \right), 0 \right\} = \sum_{i=1}^n \max \left\{ \left(\frac{M_{ij}}{T_{\cdot}} - \frac{M_{ij}^{equal}}{T_{\cdot}} \right), 0 \right\} \quad (23)$$

Eq. (22) measures the overrepresentation of women compared to men for all i in occupation j , given the overall female employment rate. Suppose that occupation j represents those higher teaching professions where women are overrepresented. Further assume that these teachers are mainly recruited from the higher social and cultural education groups where women are also overrepresented. Then (22) measures women’s overrepresentation for the particular combination (i, j) . However, it may be the case that some of the male teachers recruited come from educational backgrounds $h \neq i$ where men are overrepresented (e.g., theology). This is measured by (23). Since most workers in j are female and recruited from predominantly female types of education, $TSF_j > TSM_j$. TSM_j is therefore the smaller of the two and measures all instances where relatively more men than women work within this traditionally female occupation. The elimination of the absolute operators in (21) causes the j th component of TS to fall by an amount equal to twice TSF_j or TSM_j , whichever is the smallest. This occupation-specific factor of reintegration R_j is responsible for the difference between OS_j and TS_j : it takes OS below TS:

$$OS_j = TS_j - 2 \min\{TSF_j, TSM_j\} = TS_j - R_j \quad (24)$$

and therefore:

$$OS = TS - R \quad (25)$$

AAP’s based on reintegration can be very effective in reducing OS, even to levels below the pre-existing amount of ES. If such AAP’s can be carried out successfully, part of the impact of ES on OS can be neutralized. Here, the difference between TS and OS exactly equal to twice the amount of reintegration.

Eqs. (19), (20) and (25) show the relationships between the different measures of segregation. Substituting (25) in (20) gives:

$$OS = ES + I - D - R \quad (26)$$

This equation implies that ES is only relevant for OS as far as men and women are not reintegrated. The index $(1 - R/ES)100$ therefore represents the impact of ES on OS. The lower this impact index the less ES matters for OS. Presorting can

than be defined as $(ES - R)/OS$: the ratio between ES as far as it has impact, and OS. Section 4 illustrates Eq. (26) empirically.

4. Empirical results

In this section we examine the path from ES to OS in The Netherlands. The link between OS and ES which was identified in Section 3 shows that there are two main steps when moving from ES to OS. Firstly with inverse segregation within certain occupations more men than women are employed from a female type of education¹⁵ or more women than men are employed from a male type of education or vice versa, which occurs in a too ambitious AAP. This implies that OS and TS will not increase if the ratio of male to female workers within certain occupations with a particular educational background changes, so long as the majority group remains the majority group. An employer (e.g., economic departments of universities) who employs more women than men from an educational type which is known to be male (economists) may therefore appear to be involved in a desegregation process, but in fact forces other employers to employ the remaining men and less women. Desegregation arising from an inverse segregation situation will therefore force others to increase segregation. The combined effect of these inverse segregation situations though, is always to worsen both OS and TS.

The second step in the channel from ES to OS may contribute to the process of desegregation. By employing women from a female type of education and men from a male type of education for one occupation, OS decreases.

Table 4 shows ES for 48 education types in 1985 and 1993/1994. The table provides relative figures so that they become mutually comparable (see Eq. (5)). Negative segregation indices mean that more men than women have the educational background indicated, that is women are underrepresented. From the results, it follows that the most extreme cases of ES are found in some female types of education. Lower and intermediate vocational education that prepares for community care and hotel/catering services along with intermediate vocational education that prepares for nursing and paramedical services have relative segregation indices of more than 50%. Some typical male types of education appear to be all vocational education preparing for transport and harbour occupations and all vocational education preparing for engineering. The table also gives information on the changes in ES that have occurred between the 1985 and 1993/1994 period. On average, these changes have been small illustrating that ES in the labour force can be considered to be fixed in the short term.

¹⁵ As mentioned earlier an education is labelled as female if $F_i/T_i > F./T.$

Table 4
ES by type of education in 1985 and 1993/1994

	ES 1985 (%)	ES 1993/1994 (%)
Primary Education	-2.4	-6.1
Lower General Secondary Education	15.6	12.7
<i>Lower Vocational Education</i>		
Agriculture	-29.9	-28.8
Technical	-28.4	-31.6
Transport and Harbour	-31.9	-34.1
Commerce and Administration	26.3	23.3
Community Care, Hotel and Catering	55.5	53.8
Security	-28.1	-29.8
Higher General Secondary Education	9.1	8.6
<i>Intermediate Vocational Education</i>		
Agriculture	-27.8	-25.7
Non-Medical laboratory	-17.4	0.3
Engineering	-30.5	-30.4
Transport and Harbour	-24.7	-26.3
Medical Laboratory	38.3	40.8
Nursing and Para-medical services	52.8	52.6
Commerce and Administration	20.1	6.7
Administrative, Legal and Fiscal	-20.3	-12.4
Social and Cultural	18.8	31.9
Community Care	58.5	46.0
Hotel, Catering and Hairdressing	13.1	17.6
Police, Fire and Defense Forces	-29.5	-30.6
<i>Higher Vocational Education</i>		
Teacher Training	16.3	18.8
Interpreter and Translator	20.8	23.5
Theology	-20.7	-26.6
Agriculture	-28.9	-22.2
Non-medical Laboratory	-11.4	-6.3
Engineering	-32.3	-33.7
Higher Transport and Harbour	-30.3	-33.2
Medical Laboratory	36.6	35.7
Nursing and Physiotherapy etc.	34.6	34.8
Commerce and Administration	7.2	5.8
Business Administration Technology	-25.6	-28.5
Administrative, Legal and Fiscal	-23.2	-17.0
Social and Cultural	15.4	20.4
Hotel and Catering Industry	-11.5	0.0
Fine Arts	-1.2	2.7
Police, Fire and Defense Forces	-32.7	-31.0
<i>Academic Education</i>		
Teacher Training	-10.4	-1.2
Arts	5.9	15.8

Table 4 (continued)

	ES 1985 (%)	ES 1993/1994 (%)
<i>Academic Education</i>		
Theology	–26.2	–15.1
Agriculture	–19.0	–17.5
Mathematics and Natural Sciences	–19.5	–21.4
Engineering	–31.9	–30.4
Veterinary and Medical Sciences and Dentistry	–11.8	–9.2
Pharmacy	–6.8	–6.2
Economics, Econometrics and Business Administration	–27.1	–25.2
Law and Public Administration	–12.5	–3.4
Social Sciences	–0.5	8.6
Fine Arts	9.9	5.9

Table 5 shows how OS relates to ES in 1993/1994. The first to the fifth column describes the route from ES to OS (see Eq. (26) above). All these figures are relative figures. Compared with earlier years these figures are rather stable. Column six and seven present the index for impact of ES on OS and the index for presorting. The importance of ES for OS can already be seen from the fact that in all occupations where there is an educational overrepresentation of either sexe, there is also an occupational overrepresentation of the same sexe. The relative ES per occupation measures the ES of all workers employed within this particular occupation. Again, some female occupations provide the most extreme examples. Intermediate medical and paramedical professions have an ES of 41% and the index for intermediate service occupations is equal to 32%. Since each one of these occupations tends to recruit mainly females from different education types together, these extremes become even larger in case of OS than in the case of ES per se. Some extreme examples among male occupations are the higher mechanical and metals industry professions, intermediate construction and installation trades and intermediate police, fire, and security occupations. Presorting exceeds 100% for some occupations. The reason for this is that in these occupations the decrease in segregation is larger than the increase. As a consequence, in these occupations segregation is lowered at the expense of other occupations. Aggregated over all occupations, presorting will of course always be only a part of occupational segregation.

In practice the sex distribution over the various occupations differs from the educational sex ratios. In some educational categories that prepare for a particular occupation segregation decreases, while in others it increases. These deviations are reported in the second and third columns. As shown in Section 3, in the aggregate increases in segregation due to the postsorting process will always dominate

Table 5

Occupational segregation derived from pre- and postsorting ($OS = ES + I - D - R$)

	1993/1994						
	Educational segregation (%)	Increase (%)	Decrease (%)	Reintegration (%)	Occupational segregation (%)	(1 - R/ES)100 Impact (%)	(ES - R)/OS Presorting (%)
Lower agricultural occupations ^a	24.2	6.4	1.6	12.3	16.7	49	71
Lower technical and industrial occupations ^a	21.0	17.0	2.0	0.0	36.0	100	58
Lower food and beverage occupations ^a	22.9	7.2	3.4	4.7	21.9	79	83
Lower textile occupations	23.6	6.8	13.1	3.1	14.3	87	143
Lower wood and paper occupations ^a	25.8	11.0	1.6	0.5	34.8	98	73
Lower printing industry occupations ^a	23.8	3.3	4.4	6.4	16.4	73	106
Lower chemical industry occupations ^a	24.3	11.1	2.1	4.4	28.8	82	69
Lower metals industry occupations ^a	25.9	9.6	1.8	0.6	33.1	98	76
Lower electrical occupations ^a	22.5	3.3	2.2	16.3	7.2	28	86
Lower building materials industry occupations ^a	21.0	12.2	2.4	3.5	27.4	83	64
Lower construction and installation occupations ^a	20.9	7.7	1.7	15.8	11.2	24	46
Lower transport occupations ^a	18.9	4.5	4.2	10.0	9.3	47	96
Lower marine and inland waterway occupations ^a	24.6	11.9	0.6	0.0	35.9	100	69
Lower road and rail occupations ^a	22.2	13.5	3.8	1.4	30.4	94	68
Lower administrative occupations ^a	19.6	2.1	4.1	14.5	3.1	26	165
Lower sales and purchasing occupations	21.0	11.9	5.1	2.2	25.5	90	74
Lower hotel and catering occupations	27.1	10.1	15.6	1.7	19.9	94	128
Lower service occupations	28.3	21.9	4.0	1.0	45.1	96	61
Intermediate sports occupations	21.6	7.7	7.3	19.2	2.9	11	83
Intermediate art and design trades ^a	17.3	6.8	9.9	12.1	2.2	30	236
Intermediate technical and industrial trades ^a	22.1	8.6	3.6	1.4	25.7	94	81

Intermediate mechanical trades ^a	27.2	9.3	1.1	0.2	35.2	99	77
Intermediate electrical trades ^a	27.6	7.9	1.6	0.3	33.6	99	81
Intermediate construction and installation trades ^a	28.5	6.8	1.7	0.0	33.6	100	85
Intermediate marine and inland waterways occ ^a	25.8	11.0	0.5	0.0	36.3	100	71
Intermediate air transport and misc transport occ ^a	22.2	13.2	4.1	0.0	31.2	100	71
Intermediate medical and paramedical occupations	40.6	7.6	0.5	0.5	47.2	99	85
Intermediate administrative occupations	14.7	15.9	1.7	4.2	24.7	71	43
Intermediate sales and purchasing occupations ^a	15.7	9.1	5.7	4.8	14.3	69	76
Intermediate socio-cultural occupations	14.6	6.1	6.1	10.2	4.4	30	100
Intermediate hotel and catering occupations	23.4	4.9	12.3	10.9	5.1	53	245
Intermediate service occupations	32.4	15.3	0.5	0.0	47.1	100	69
Intermediate police, fire, and security occupations ^a	26.7	5.8	5.0	1.3	26.2	95	97
Intermediate military occupations ^a	25.6	11.2	3.6	0.2	33.0	99	77
Higher teaching professions	17.4	1.5	2.5	6.3	10.1	64	110
Higher literary professions	14.9	19.2	0.3	4.6	29.2	69	35
Higher theological vocations ^a	18.3	4.6	1.9	1.2	19.8	93	86
Higher professions in the arts and design	11.6	2.9	4.7	6.9	2.9	41	162
Higher agricultural professions ^a	20.9	7.2	0.1	5.4	22.6	74	69
Higher technical and industrial professions ^a	24.0	3.8	3.0	1.0	23.7	96	97
Higher mechanical and metals industry professions ^a	29.5	7.1	0.7	0.3	35.5	99	82
Higher electrical professions ^a	30.5	5.7	0.4	0.0	35.7	100	85
Higher construction and installation professions ^a	29.1	3.6	0.6	0.0	32.0	100	91
Higher medical and paramedical professions	21.3	4.7	3.2	9.2	13.6	57	89
Higher commercial and administrative professions ^a	16.4	13.1	7.7	2.4	19.5	85	72
Higher administrative professions ^a	15.5	12.2	5.2	0.7	21.9	95	68
Higher legal and government professions ^a	10.3	3.3	4.5	2.4	6.7	77	118
Higher socio-cultural professions	19.1	6.2	1.2	3.8	20.2	80	76
Total	21.6	10.0	3.3	4.5	23.8	79	72

^aIndicates educational overrepresentation of men.

decreases. For most occupations it is, in accordance with this general rule, found that any increase in segregation is larger than any decrease. Important exceptions to this rule occur with both intermediate and lower hotel and catering occupations and lower textile occupations. This implies that these occupations tend to employ workers with different educational backgrounds in ratios which are closer to the equal distribution than ES suggests (see the upper left and lower right sections of Table 3). Other occupations therefore have to accept more extreme proportions of women or men. In 1985 the number of occupations where decreases in segregation were larger than increases was equal to 4 out of 48. In 1993/1994 in 10 out of 48 cases occupations this situation occurred. Therefore, there seems to be a tendency in many occupations to 'correct' the distribution induced by ES.

An overall reduction of OS is only possible through reintegrations. Table 5 shows that some occupations will to a large extent combine female workers from female types of education with male workers from male types of education. The most important instances of reintegration occur in lower electrical occupations, lower construction and installation occupations, lower administrative occupations and intermediate hotel and catering and sports occupations. It may seem surprising that one of the largest reintegration of men and women occurs in the lower electrical occupations. This occupation involves tasks which include the assemblage of printed circuit boards, a job which is often fulfilled by women. In fact this job has no specific skill requirements. It is therefore possible that men are recruited from the lower technical education groups, while women are recruited from other lower vocational education groups where they are overrepresented. The high reintegration component in the other occupations is less surprising. Lower administrative occupations and jobs in hotel and catering services may be filled by both men and women with different educational backgrounds as they are able to learn the job specific skills required.

Presorting due to ES, increases and decreases in segregation and reintegration all result in OS. The segregation in the lower service occupations, i.e., typical female occupations, is to a large extent due to postsorting. Here, the index for presorting due to ES is equal to 61%. ES equals 28.3. Since reintegration is only 1% the impact of ES on OS equals 96%. Postsorting adds 22% and subtracts 4% from this. However, for the intermediate medical and paramedical occupations, which are also typically female in nature, segregation is mainly due to presorting (85%). Occupations which are typically male in nature include those in the higher mechanical and metals industries and higher technical professions. Segregation here is mainly due to presorting (82% and 97% respectively). However, segregation in the lower technical and industrial occupations is much more due to postsorting (presorting equals 58%). Occupations in which presorting is less than 50% are rare. Only for the higher literary professions (35%) and the intermediate administrative occupations (43%) postsorting is more important than presorting.

As stated, an increase in segregation is only possible if certain combinations of occupation and education type lead to inverse segregation. Table 6 provides

Table 6
Frequency of the ordering of F_{ij}^{equal} , F_{ij}^{educ} and F_{ij} in 1993/1994

Ordering	%	Description
$F_{ij}^{\text{educ}} < F_{ij} < F_{ij}^{\text{equal}}$	10.5	decreased segregation of a male type of education
$F_{ij} < F_{ij}^{\text{educ}} < F_{ij}^{\text{equal}}$	30.3	increased segregation of a male type of education
$F_{ij} < F_{ij}^{\text{equal}} < F_{ij}^{\text{educ}}$	21.1	inverse segregation of a female type of education
$F_{ij}^{\text{educ}} < F_{ij}^{\text{equal}} < F_{ij}$	7.0	inverse segregation of a male type of education
$F_{ij}^{\text{equal}} < F_{ij}^{\text{educ}} < F_{ij}$	19.5	increased segregation of a female type of education
$F_{ij}^{\text{equal}} < F_{ij} < F_{ij}^{\text{educ}}$	11.6	decreased segregation of a female type of education
Total	100	

information about the frequency of all situations (corresponding to the six sections of Table 3). The frequency among all (i, j) where the fraction of male workers coming from a female type of education in some particular occupation exceeds the overall participation fraction of men and vice versa is 21.1% and 7.0% respectively. Hence, almost one third of all (i, j) are characterized by inverse segregations.

If F_{ij}^{educ} is less than F_{ij}^{equal} , then education i is predominantly male (see Eqs. (8)–(11) above). The third and fourth rows of the table show that inversions are more frequent for female than male education types.¹⁶ Many occupations tend to employ men rather than women from these female types of education. The frequency among all (i, j) is even higher than the more ‘usual’ orderings of female types of education where there is an increase or decrease in segregation (the two lower right sections of Table 3). For male types of education, this tendency is less strong. But still, in 7% of all cases this situation occurs. Finally, there are more cases where there are only increases in segregation (30.3% + 19.5%) than where there are only decreases in segregation (10.5% + 11.6%).¹⁷

Table 7 shows the segregation indices at an aggregated level for the 1979–1993/1994 period. While ES increased during these years, OS decreased. The impact of ES on OS remained fairly constant with 1993/1994 as an exception. Presorting increased substantially, however, from 61% in 1979 to 72% in 1993/1994. As a consequence, the gap between ES and OS decreased from 6.9% in 1979 to 2.2% in 1993/1994. This is equal to the net effect of the increase, decrease and reintegration which together are responsible for the gap. The increase in segregation due to postsorting fell by 2%-point to 10%, and the decrease rose

¹⁶ This means that for all (i, j) the upper right section of Table 3 prevails more often than the lower left section.

¹⁷ Increases only occur in the two middle pictures of Table 3 where there are movements away from the distribution induced by educational segregation as well as from the equal distribution. Decreases only occur in the upper left and lower right sections, which represent movements away from the distribution induced by educational segregation but towards the equal distribution.

Table 7

The link between educational and occupational segregation from 1979 till 1993/1994

	1979	1981	1983	1985	1993/1994
Educational segregation	17.9	18.5	19.9	20.8	21.6
Increase	12.0	12.2	12.0	11.4	10.0
Decrease (–)	2.4	2.2	2.4	2.7	3.3
Reintegration (–)	2.8	3.1	3.4	3.4	4.5
Occupational segregation	24.8	25.2	26.0	25.9	23.8
Impact (%)	84	83	83	84	79
Presorting (%)	61	61	63	67	72

by 0.9%-point. Finally, reintegration increased sharply by 1.7%-point to 4.5%. In the previous sections we distinguished between two components of postsorting. The first component, i.e., the degree to which women and men with the same type of education are directed towards different occupations (measured by the combined impact of any increase and any decrease), may enlarge the gap between ES and OS. This now becomes less important. The second component, namely reintegration, i.e., the bringing together of sexes with different educational backgrounds into the same occupations and thus narrowing the gap, now becomes more important.

It may be reasonable to expect that a high degree of both ES and OS will be with us for at least the next two decades. Still, some specific policy measures can be undertaken in order to attenuate these segregations. Firstly, governments can take special measures to increase the number of the underrepresented group in educations where there is a high sex-segregation among students. This policy bears fruit in the long term only. In the short term, the government can try to motivate employers to recruit more women (men) with a predominantly female (male) background into typically male (female) jobs. These reintegration-based AAP's can be very effective, whereas short-sighted AAP's are of no avail, at least in the short term.

5. Conclusions

The main aim of this paper was to disentangle the relationship between ES and OS, and in doing so, investigate whether OS between men and women is predetermined by educational presorting. We constructed new segregation indices which measure the relative importance of pre- and postsorting in the OS more accurately. It can safely be concluded that ES is a major cause of OS. Over-ambitious (and ineffective) AAP's can only increase OS and TS. Segregation may be reduced by employing both men from male types of education and women from female types of education in one occupation. The relative importance of this

process, which we termed reintegration, increased between 1979 and 1993/4, but the extent of this reintegration is still quite modest. The combined effects of postsorting, additional segregation and reintegration, is too small to counterbalance the effect of ES on OS. Over time however, ES tends to rise while OS becomes smaller. The reduction of the gap between ES and OS is mainly due to increased presorting, but is also due to an increase in reintegration. As a final point, the method which we have developed can be used whenever one is able to distinguish between two groups and when one distribution partly determines another distribution, e.g., when the distributions of children from poor and rich families over educations and occupations differ.

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