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Tal Modai-Snir
Delft University of Technology

Maarten van Ham
Delft University of Technology and IZA

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IZA – Institute of Labor Economics

Schaumburg-Lippe-Straße 5–9
53113 Bonn, Germany

Phone: +49-228-3894-0
Email: publications@iza.org

www.iza.org

ABSTRACT

Structural and Exchange Components in Processes of Neighbourhood Change: A Social Mobility Approach

Neighbourhood socioeconomic change is a complex phenomenon which is driven by multiple macro- and micro-level processes. Most theoretical and empirical work has focused on the role of urban-level processes, such as filtering, life-cycle, and social dynamics. For individual neighbourhoods, these processes generate flows of different socioeconomic groups, which consequently leads to an exchange of relative positions in the metropolitan hierarchy ('exchange' effect) where some neighbourhoods move up and others move down. Neighbourhoods are also affected by structural processes that operate beyond the urban level. They can generate upward or downward shifts of absolute income across a whole array of neighbourhoods ('growth/decline' effect), or change the inequality among neighbourhoods, where the top and bottom of the neighbourhood hierarchy move away from each other ('inequality' effect). A common practice in neighbourhood change studies is to represent neighbourhood status as relative to the respective metropolitan area; this neutralizes the 'growth/decline' effect and ignores an important source of change and divergence between neighbourhoods in different regions. Some specific relative measures of change do capture the 'inequality' effect but confound the 'exchange' and 'inequality' effects. This paper introduces a methodological approach that decomposes total neighbourhood socioeconomic change, measured in absolute terms, into components of 'exchange', 'growth/decline' and 'inequality'. It applies a decomposition method presented by Van Kerm (2004), developed for understanding income mobility of individuals. The approach (1) acknowledges the role of structural processes in neighbourhood change, and (2) makes a distinction between different processes that generate neighbourhood change which is essential for comparative research.

JEL Classification: O18, P25, R23

Keywords: urban change, neighbourhood change, structural processes, relative change, absolute change, inequality

Corresponding author:
Tal Modai-Snir
OTB – Research for the Built Environment
Faculty of Architecture and the Built Environment
Delft University of Technology
P.O. box 5043
2600 GA, Delft
The Netherlands

E-mail: t.modai-snir@tudelft.nl

1. Introduction

The socioeconomic status of urban neighbourhoods can change over time due to multiple processes. Some of these processes operate at the urban level; they generate residential mobility flows of different income groups that change the socioeconomic makeup of neighbourhoods. Several models have dealt with explaining these flows and consequent neighbourhood socioeconomic change. The life cycle model (Hoover and Vernon 1959) and filtering model (Muth 1973; Sweeney 1974a, 1974b) view neighbourhood decline and renewal as cyclical processes that are related to the neighbourhood stage of development and the deterioration of its housing stock. Models of social dynamics, such as Schelling's (1971) segregation model, show how households' preferences for living among similar households generate ethnic and socioeconomic sorting that consequently changes neighbourhood makeups. Also, changes in spatial amenities can explain patterns of change in neighbourhood status that are related to the urban level.

Beyond the urban level, neighbourhood socioeconomic conditions are also affected by structural processes that involve regional, national or even global levels. These processes can generate changes in the distribution of socioeconomic characteristics of the population in an urban area, which can translate into neighbourhood change. Overall socioeconomic levels can increase or decrease at the regional or national level, and consequently they can increase or decrease at the neighbourhood level (Galster et al. 2003; Zwiers, Bolt, et al. 2016). Also changing levels of inequality in society can affect neighbourhoods (Andersson and Hedman 2016) and socioeconomic segregation (Reardon and Bischoff 2011; Watson 2009).

These various processes represent distinct effects on neighbourhood socioeconomic conditions. Urban-level processes generate an 'exchange' effect which implies that over time, neighbourhoods exchange relative positions in their urban or metropolitan hierarchy. In the absence of any change in overall population characteristics, it is a zero-sum process that simply circulates advantage and disadvantage among urban neighbourhoods. 'Structural' effects refer to processes that operate beyond the urban level; they include the 'growth/decline' and 'inequality' effects. The former refers to the overall upward or downward change in socioeconomic conditions among all neighbourhoods in an urban area, and the latter to the change in the inequality among them. Research to date has mainly focused on the 'exchange' effect, which is reflected in the urban models and methods used to measure neighbourhood change.

We currently know very little about the relative roles of structural and exchange processes in neighbourhood change. More insight into the different processes can help to understand, for example, to what extent neighbourhoods change because they increase/decrease relative to other neighbourhoods in the urban area or because urban or national economics drag them up or down. It can also provide insight into the extent to which neighbourhoods are affected by increasing income inequality.

The almost exclusive focus on exchange processes in studies of neighbourhood socioeconomic change is reflected in how neighbourhood status is measured. Most commonly, it is measured as relative to other neighbourhoods in the respective metropolitan area (Choldin et al. 1980; Choldin and Hanson 1982; Delmelle 2015; Fogarty 1977; Gould Ellen and O'Regan 2008; Landis 2016; Logan and Schneider 1981; Owens 2012; Rosenthal 2008; Rosenthal and Ross 2015). The common justification, as brought by Logan and Schneider (1981), is that as opposed to absolute measures, relative measures avoid confounding processes that change neighbourhoods' relative statuses within regions with

processes that lead to economic change among regions. Relative measures indeed neutralize the effect of metropolitan growth or decline on neighbourhood change. However, a specific relative measure which is often used (ratio of neighbourhood average income to the average for neighbourhoods within the respective metropolitan area) does capture the effect of change in inequality. Such measures confound, therefore, urban-level 'exchange' processes with the change in inequality among neighbourhoods. Using such a measure attributes all relative change to urban processes while some of it may actually be a result of a change in inequality.

This paper proposes an approach to measure neighbourhood socioeconomic change that is based on methods in income mobility research. This method is capable of distinguishing between the different components of change as introduced above. It is presented by looking at neighbourhood average income, but can be applied using any other socioeconomic indicator. Social and income mobility research have long been making the distinction between exchange and structural components with regard to mobility measurement. Two previous studies have applied a similar approach in the neighbourhood and urban context (Collver and Semyonov 1979; Congdon and Shepherd 1988), partially based on the work of McClendon (1977). This paper, however, challenges the conceptual underpinnings of the components derived by these authors. The objective of this paper is to advance the approach by considering more recent methodological contributions in income mobility research. Specifically, this paper uses a decomposition method presented by Van Kerm (2004).

The remainder of this paper offers a theoretical background on the distinction between exchange and structural processes in neighbourhood change, including a discussion on the conceptual implications of common practices in the measurement of neighbourhood change. The following section introduces the theoretical and methodological background related to structural and exchange processes in the fields of social and income mobility, including the decomposition procedure by Van Kerm (2004). Finally, the approach is illustrated using a hypothetical numeric example, followed by a discussion.

2. Theoretical Background

2.1 Neighbourhood change and urban-level processes

Residential mobility flows of different income groups change the socioeconomic positions of neighbourhoods relative to other neighbourhoods in the same urban area. Neighbourhoods move up in the hierarchy when people who move in have higher incomes than those who move out, and decline when the opposite flows occur. There are various theories and models which use these selective flows to explain change.

An influential class of models depicted neighbourhood socioeconomic change as a cyclic process. The early 'invasion-succession' model developed by Chicago School sociologists (Park 1952) suggested that low-income households take the place of higher-income households who gradually move outward to newer neighbourhoods at the urban fringe. Two other models complement this view; the Life cycle model (Hoover and Vernon 1959) suggests that neighbourhoods move chronologically through stages of development, characterized by gradual decline, until they reach a point that reinvestment is economically worthy and go through a process of renewal. The filtering model (Muth 1973; Sweeney 1974a, 1974b) emphasizes the role of the deterioration of the neighbourhood's housing stock in generating neighbourhood decline. It drives away affluent households to newer neighbourhoods while the vacated housing filters down to lower-income households. Empirical studies asserted, in

general, the life-cycle and filtering view (e.g. Brueckner and Rosenthal 2009; Choldin et al. 1980; Choldin and Hanson 1982; Rosenthal 2008; Rosenthal and Ross 2015), indicating a pattern of mean reversion; high-income neighbourhoods typically experience decline while low-income ones experience increase. Specifically, Rosenthal (2008) found that it takes, on average, about 100 years for neighbourhoods to cycle back to their initial income level.

Other urban-development processes can also explain neighbourhood socioeconomic change, regardless of the life-cycle stage. Transportation innovations such as commuter networks, for example, have found to be one of the drivers of the historical flight of high- and middle-income households to the suburbs (Anas et al. 1998), with its long-lasting effects on city-centre decline in many metropolitan areas, especially in the US. The suburbanization of employment has also contributed to that decline (Wilson 1987). Urban development may also exert local influence on neighbourhood increase or decline through planning and policies. Meen et al. (2012) mentioned, for example, the role of environmental improvements and land-use conversions in changing the fortunes of low-income neighbourhoods in Melbourne.

The preference of people for living among people similar to themselves is also central in generating selective mobility flows and consequent neighbourhood change, as demonstrated in Schelling's (1971) seminal model. The model shows that even slight preferences for own-group presence in the residential neighbourhood can generate selective mobility flows and lead to segregation. Social dynamics are self-reinforcing as the increasing presence of own-group households further attracts similar households; thus, they can either accelerate the pace of socioeconomic change or make status persistent (Rosenthal 2008; Rosenthal and Ross 2015). Housing market dynamics also play a role in reinforcing the process of change, as changes are quickly manifested in housing prices. The literature on gentrification, for example, describes how an initial inflow of high-income households can increase housing prices and trigger the displacement of existing low-income residents (e.g. Atkinson 2000; Marcuse 1986). Some local amenities, such as retail and public services, also take part in these dynamics; their location reflects the presence of certain socioeconomic strata in the neighbourhood, but at the same time they further attract other households of similar status (Glaeser and Gyourko 2005; Rosenthal and Ross 2015).

There is also a group of neighbourhoods that persistently occupy a stable relative position in the overall hierarchy. Rosenthal's study (2008), indicated that a third of all neighbourhoods remained in the same income quartile over a period of 50 years. While certain urban processes explain how selective mobility flows occur and generate neighbourhood change, some urban features explain how in and out flows of similar income strata are maintained and generate persistence in neighbourhood status. Landscape features (Lee and Lin 2013; Meen et al. 2012) and historical city centres (Brueckner et al. 1999), for example, represent fixed advantages among specific neighbourhoods and generate persistent affluence. In contrast, negative features, such as environmental problems or inferior accessibility, can generate persistent deprivation to the extent that these settings cannot be easily improved.

The relative position of neighbourhoods can also change as a result of urban renewal policies. The displacement of low-income households from deprived neighbourhoods is often the outcome of urban restructuring policies that aim at creating social mix through physical changes to the housing stock (Andersson and Bråmå 2004; Andersson and Musterd 2005; Bolt and van Kempen 2010). Common criticism related to such policies is that problems associated with poverty do not disappear due to such interventions, but move to other places within the urban area (Andersson and Musterd 2005). This depiction, of ‘moving disadvantage’ can be generalized to all income strata, as well as to other driving mechanisms.

As long as population characteristics do not change, urban-level processes simply move advantage and disadvantage across space.

A simple illustration in Figure 1 explains the exchange process of neighbourhood change. Suppose that a given metropolitan area contains 4 neighbourhoods (*a,b,c,d)* each containing 10 households, with a total number of 40 households. For the sake of simplicity, there are only two income groups, rich and poor, each constituting 20 households in total. At the initial observation (t=0) neighbourhoods *b* and *c* occupy the highest and lowest metropolitan positions respectively, and neighbourhoods *a* and *d* occupy the middle positions. The selective mobility flows of poor and rich households between these neighbourhoods (middle panel) changes their makeups and in the second observation (t=1) neighbourhoods occupy different positions in the metropolitan hierarchy, compared to their previous one. The assumptions underlying this model are that the distribution of households among income categories remains identical over time, and that the metropolitan structure is identical with regard to the distribution of neighbourhood statuses, as it is assumed that the tendency to segregate is fixed in the absence of any exogenous factor.

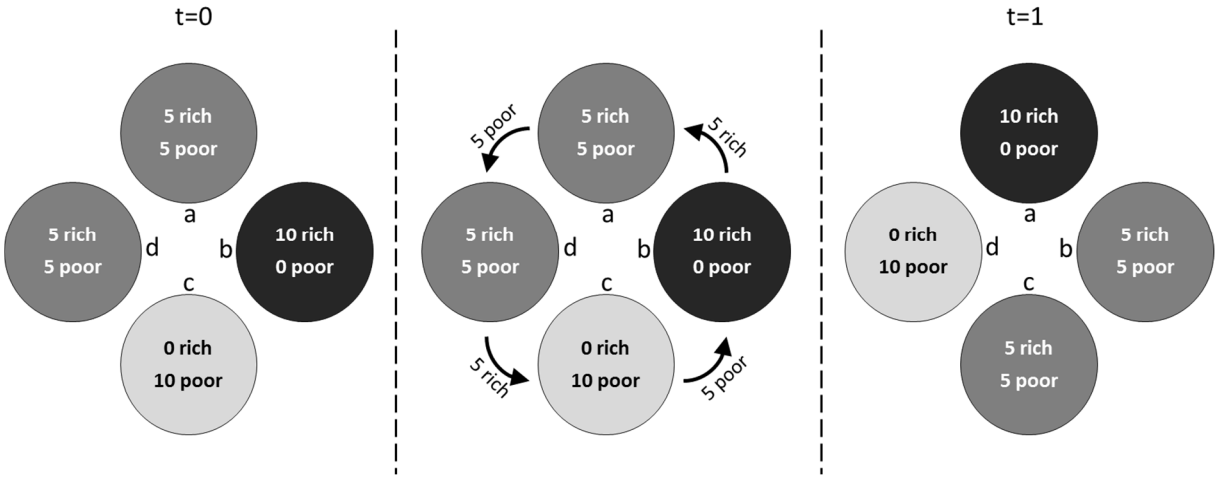

Figure 1 The exchange of neighbourhood relative positions as a result of selective mobility flows

2.2 Neighbourhood change and structural processes

Regardless of the repositioning of neighbourhoods within the urban hierarchy, various processes can drive changes in the absolute socioeconomic conditions of neighbourhoods. These processes, which are termed hereafter as structural, operate beyond the urban level and affect neighbourhood absolute conditions by changing the socioeconomic makeup of the metropolitan population. One of them, is the upward or downward change in overall socioeconomic conditions (termed hereafter the 'growth/decline' effect). neighbourhood changes can result from overall income growth or decline which follows from macro-economic and demographic processes throughout the country or in specific regions. In rust-belt metropolitan areas in the US, for instance, neighbourhood socioeconomic decline mirrored the decline of whole cities due to the shrinking of the industrial sector (Rosenthal and Ross 2015). Beyond the regional level, Zwiers et al. (2016) illustrated how even global processes may translate into decline among individual neighbourhoods.

Another type of structural process that can affect socioeconomic conditions of individual neighbourhoods is the change in the dispersion of the neighbourhood income distribution

within an urban area. Such change is likely to result from changing economic inequality among individuals in the region or in society as a whole (hence termed the 'inequality' effect). Increasing inequality among individuals results in increasing disparities among neighbourhoods due to two different mechanisms (Andersson and Hedman 2016); first, when incomes of the rich and poor diverge, the average incomes of their respective places of residence follow the same path through an *in situ* process. Secondly, increasing income inequality generates intensified selective mobility because of the increased disparities between the rich and poor in the resources available to spend on housing. For example, in the US, increasing income segregation has been associated with increasing inequality among individuals (Reardon and Bischoff 2011; Watson 2009). Also, the decline in the proportion of middle-income neighbourhoods seems to correspond to a similar decline in the proportions of middle-income families in the overall population (Booza et al. 2006).

To summarize, neighbourhood socioeconomic change is a result of distinct processes operating at different levels: the urban level, which is associated with the 'exchange' effect, and higher (inter-regional, national or global) levels which are associated with structural effects. The latter combine both the 'growth/decline' and 'inequality' effects. Figure 2 explains this distinction by illustrating the metropolitan socioeconomic hierarchy of neighbourhoods as a ladder. Each echelon signifies a certain socioeconomic position within the metropolitan hierarchy, occupied by a certain neighbourhood at each point in time. Each pair of ladders denotes a transition from one point in time to another, over which one can observe the changes occurring to the whole array of neighbourhoods and to each individual one. The left scheme illustrates the pattern of changes occurring among neighbourhoods due to the exchange of relative positions. The socioeconomic statuses incurred by each position on the ladders are identical across the two observations, and neighbourhoods just swap places among themselves. The middle scheme depicts the kind of change expected during a period of income growth. The socioeconomic level entailed by each position is higher at the second observation. During a period of overall decline socioeconomic levels among all positions would be lower. The right scheme visualizes the effect of changing inequality on neighbourhood change. In this example the distribution widens such that high-positioned neighbourhoods experience increasing of socioeconomic levels and low-positioned neighbourhoods experience a decrease. The opposite could happen if the distribution became more equal; the ladder scheme would depict positions which are closer to the average level, with smaller socioeconomic gaps among positions.

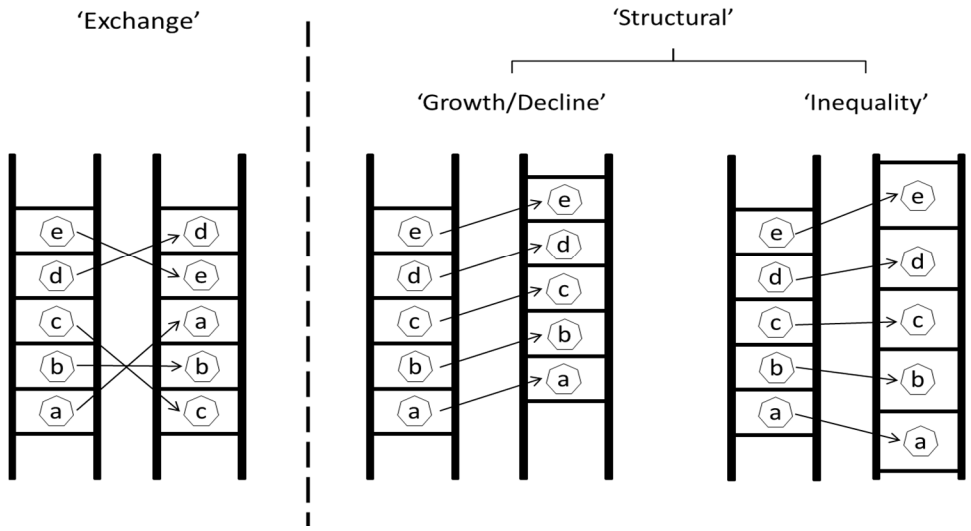

Figure 2 A conceptual distinction among processes of neighbourhood socioeconomic change

2.3 Current measures of neighbourhood change and their limitations in reflecting the complexity of processes

There are various ways to measure neighbourhood status change, and each captures a different combination of the 'exchange', 'growth/decline' and 'inequality' processes of change. Many studies measure neighbourhood change based on the status of neighbourhoods relative to their respective metropolitan area (e.g. Choldin et al. 1980; Choldin and Hanson 1982; Delmelle 2015; Fogarty 1977; Gould Ellen and O'Regan 2008; Landis 2016; Logan and Schneider 1981; Owens 2012; Rosenthal 2008; Rosenthal and Ross 2015). These measures eliminate the effect of metropolitan income growth or decline. So, if a neighbourhood is located in an economically declining or growing urban area, the absolute socioeconomic change implied by this process will not be captured when a relative measure is used. Relative measures understate, therefore, the upward or downward amount of change (Gould Ellen and O'Regan 2008; Jun 2013) and their use results in overlooking an important source of divergence in neighbourhoods' conditions across metropolitan areas.

Neighbourhood socioeconomic change has also been measured based on status relative to other reference levels, for example, to the average of a cross-metropolitan sample of neighbourhoods (Jun 2013; Zwiers, Kleinhans, et al. 2016). By using this reference level, measures account for processes that affect the disparities in growth or decline among metropolitan areas (or cities) included in the sample. However, other structural processes that lead to overall growth or decline may still not be accounted for; for example, changing income disparities among metropolitan and rural areas or among sampled and non-sampled metropolitan areas, and a national growth/decline in incomes. Measuring neighbourhood change relative to the average of a national sample of neighbourhoods may account for all structural processes except a national increase or decline in incomes.

The higher the spatial scale used as a reference for neighbourhood status measurement, the more processes of change can be captured. Figure 3 illustrates that principle in three different cases (*a*,*b*,*c*). In each of the cases the outer boundary represents a whole region or a country, smaller circles represent metropolitan areas or cities and grey spots represent the smallest spatial units, referring to neighbourhoods or villages in urban and rural areas respectively. In case *a* neighbourhood change is measured based on status relative to the city- or metropolitan average; thus it only captures the effect of processes operating within the respective boundaries. Case *b* represents a situation where the reference level is the average of neighbourhoods across a sample which includes several cities or metropolitan areas. Consequently it captures processes that produce disparities among the sampled spatial units but overlooks those that may produce spatial disparities among sampled and non-sampled areas. Finally, case *c* shows that a reference level of a regional or country average captures all processes within that boundary; however, processes that operate beyond that level are still left out. Only a measure that is based on absolute income values would capture the overall amount of neighbourhood change associated with growth or decline processes. Using them, however, cannot indicate whether neighbourhoods changed relative to other metropolitan neighbourhoods or whether their change is related to the overall metropolitan, regional, or national increase or decline, and this is why relative measures have been used in the first place; they were assumed to isolate urban-level from higher-level structural processes (Logan and Schneider 1981).

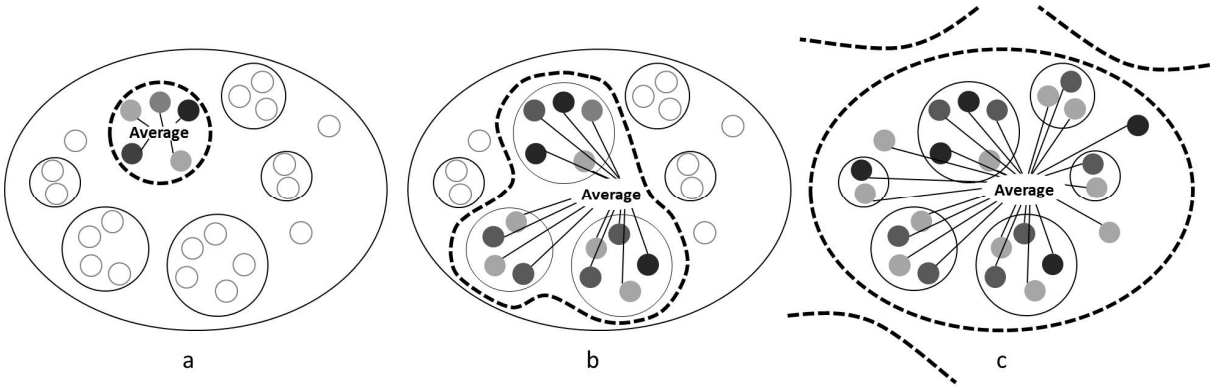

Figure 3 Using different spatial scales as reference levels in neighbourhood change measures

However, the most common relative measures do not completely control for structural processes. Measures that are based on computing the ratio of neighbourhood average income to the average for all neighbourhoods in the respective metropolitan area (e.g. Fogarty 1977; Gould Ellen and O'Regan 2008; Logan and Schneider 1981; Rosenthal 2008; Rosenthal and Ross 2015), and to a lesser extent also those that are based on standardized scores (e.g. Delmelle 2015) do in fact capture the 'inequality' effect and therefore confound it with the 'exchange' effect. This can lead to the inconsistency of research designs with theoretical models, because the effect of changing inequality on neighbourhoods is incorporated in the total observed change which is attributed to urban-level processes. For example, increasing income inequality is expected to increase the absolute socioeconomic levels of the highest-positioned neighbourhoods and decrease those of the lowest status ones. This pattern can counteract the typical mean-reversion pattern associated with urban filtering, where high-income neighbourhoods move down and low-income ones move up. In that case, the amount of change attributed to urban-level processes can be understated.

It follows that most of the neighbourhood change literature neglected the overall effect of higher-level structural processes and also confounded different processes in their analyses. It also follows that to fully account for all structural processes absolute measures should preferably be used. But at the same time, the contributions of different processes of change have to be distinguished from each other to be able to compare neighbourhood change between, for example, different cities, and to be able to examine theoretical models that focus on specific sources of change. Two previous studies, suggested approaches that comply with this strategy. They decomposed total neighbourhood and urban change (measured in absolute terms) into contributing components (Collver and Semyonov 1979; Congdon and Shepherd 1988). Although we have some reservations about the conceptual implications underlying the derived components (which are discussed in the next section), the approach appears beneficial. This methodological direction has, nevertheless, not been further advanced, and the use of relative measures that eliminate the 'growth/decline' effect and often confound the 'inequality' and 'exchange' effects has remained the standard practice.

This paper follows this abandoned route of neighbourhood change research; it proposes the application of an alternative decomposition procedure of total neighbourhood change to components reflecting 'exchange' and two different 'structural' effects, 'growth/decline' and 'inequality'. The approach builds on methodological advancements in decomposing total mobility to its contributing 'exchange' and 'structural' components from the field of individual income mobility.

3. A social mobility approach to decomposing total neighbourhood change

The research field of social and income mobility of individuals also struggles with the decomposition of total mobility into structural- and exchange-mobility components. This paper proposes to use such a method and apply it to neighbourhood change research.

Social mobility deals with the changes in individuals' social and economic positions through time. Sociologists have typically focused on transitions between parent's and offspring's' socio-occupational positions. In this context, structural mobility has been referred to as the class mobility of individuals that is induced by the changing availability of occupational positions across class categories, due to technological development or other structural processes. Exchange mobility has been regarded as the movement of individuals among positions within a given distribution of positions among social classes (Markandya 1982). Welfare economists are focused on the evolution of economic well-being; with incomes at the centre of attention, the field is more specifically termed 'income mobility'. Here, structural mobility refers to changes in individuals' incomes which result from changes in the distribution of income, and exchange mobility is referred to as the change in individuals' relative positions within a given distribution of incomes (Markandya 1982).

In the social and income mobility research there is a lack of consensus as to whether structural mobility matters. For example, welfare economists are divided by those who consider the change in individuals' incomes resulting from overall growth as mobility, and those who do not. The latter, referred to as taking a relativist approach, would argue that substantial mobility only occurs if individuals experience change in relative positions across the income distribution [see Fields (2008) for a more detailed explanation on relative versus absolute mobility]. It is agreed, however, that exchange and structural effects have to be distinguished from each other. Basically, this is done by quantifying the total amount of mobility and by decomposing it to reflect the contributions of the different effects. Yet, there are several distinctive conceptualizations of mobility (Fields 2008; Fields and Ok 1999a), and correspondingly, there are also different ways to measure it and to reflect its underlying components. Silber (1995), for example, presented a decomposition of total distributional change to a component generated by inequality change and a component reflecting the exchange of positions. The 'total mobility' decomposed in this case adheres to a relative concept of mobility and thus it excludes the 'growth/decline' component which we, in the context of this paper, do seek to account for. Another procedure, proposed by Ruiz-Castillo (2004), decomposes the mobility measure by Chakravarty et al. (1985) which is based on an ethical approach to mobility. The concept underlying this measure does not suit, in our opinion, the analysis of neighbourhood change. These two methods are therefore not applicable in the context presented in this paper.

Two papers introduced variants of another decomposition strategy and applied it in the context of neighbourhood and urban change (Collver and Semyonov 1979; Congdon and Shepherd 1988); both are partially based on previous work of McClendon (1977). They decompose the sum of squared differences between final and initial neighbourhood indicator values, and derive three similar components of change defined as 1) changes in the average over all neighbourhoods or areas 2) changes in the dispersion of the distribution of indicator values and 3) changes in the relative positions of neighbourhoods. These components can be regarded as the equivalents of the 'growth/decline', 'inequality' and 'exchange' effects respectively. The first component is expressed in both papers as the difference between final and initial overall means. This statistic is inconvenient in a comparative context, where a ratio statistic would be preferable. The second component is expressed by Collver & Semyonov as

the difference in standard deviations of final and initial distributions. Congdon and Shepherd's respective component is based on the beta coefficient computed from regressing final on initial indicator values and therefore it is also dependant on the relationship between final and initial standard deviations. We have reservations about the underlying properties of these derived components. Standard deviations are scale-variant and translation-invariant; scaling a variable changes the standard deviation proportionately, and adding a constant amount to a variable does not change the statistic. This is contrary to the axioms underlying the most commonly used inequality measures (for example the Gini index). Finally, the exchange component is expressed by Collver & Semyonov as the difference in standardized scores. The change in standardized scores is not void of structural influences[1]. In case of significant change in the shape of the distribution standardized scores are affected and therefore do not 'purely' account for exchange processes. Our suggestion of applying an alternative decomposition rests therefore on the grounds of conceptual perception regarding the derived components.

4. A method for decomposing total neighbourhood change into structural and exchange components

We propose the application of a decomposition presented by Van Kerm (2004). This procedure decomposes mobility measures to represent the relative contributions of 'growth/decline', 'inequality' (termed 'dispersion' by Van Kerm) and 'exchange' components of income mobility processes. It has the advantage of offering a general framework that can be applied to different mobility measures which could be chosen to conform to a particular research context. The procedure is based on the construction of counterfactual income vectors, each incorporating only the effect of one factor on the initial vector of incomes, while the effect of the other two factors is neutralized. Van Kerm (2004) specified three functions that can be used to derive the three counterfactual vectors. We explain the underlying rational, referring to the context of neighbourhood change [refer to Van Kerm (2004) for the technical overview and formulas which relate to the income mobility context]:

1) The 'exchange' counterfactual vector is constructed such that it orders the vector of initial neighbourhood incomes according to the rank orders of the vector of final neighbourhood incomes. It reflects therefore the change in positions while eliminating the other effects.
2) The 'structural' counterfactual vector is constructed such that it orders the vector of final neighbourhood incomes according to rank orders of the vector of neighbourhood initial incomes. It reflects therefore the changes in absolute incomes while eliminating the effect of changes in neighbourhoods positions.
3) The 'growth/decline' counterfactual vector is constructed by 'inflating' (or 'deflating') the initial vector of neighbourhood incomes by the ratio between the overall averages of final and initial neighbourhood incomes.
4) The 'inequality' counterfactual vector applies the Lorenz curve of the vector of final incomes to the vector of initial incomes.

The next step in this approach, is to quantify the total amount of change, and the amount associated with each counterfactual vector using a measure of mobility. Total change is computed using the initial and final observed vectors of neighbourhood average income.

[1] As McClendon (1977) himself noted in footnote 3, p. 60.

Component contributions are separately computed by using each counterfactual vector instead of the observed vector of final incomes. But first one should consider which mobility measure should be used. Van Kerm (2004) listed several applicable mobility measures, which comply with required axioms. Among them, we chose to use the measure proposed by Fields and Ok (1999b). Its advantage is that due to its structure of aggregated change among all neighbourhoods it can be simply disaggregated to reflect the contributions of groups of neighbourhood, a property which is highly desirable in the neighbourhood change context. The measure is defined as:

$$m_n(x, y) = \frac{1}{n}\sum_{i=1}^{n}|\log y_i - \log x_i|$$

where (in the context of this application), y_i and x_i are neighbourhood average incomes at the final and initial observation periods respectively, and *n* refers to the number of neighbourhoods. This measure conforms to a concept of movement that focuses on the distance between final and initial values given in absolute terms (referring to dollar income). Due to the absolute value notation the measure would represent the average movement of incomes among neighbourhoods regardless of the directions of change; otherwise, the exchange component would sum up to zero. In computing contributions of neighbourhood sub-groups, a directional measure should be used by omitting the absolute value bars in the equation presented above. This variant of the mobility measure would reflect both the magnitude and direction of change experienced by each individual neighbourhood or group of neighbourhoods.

Finally, Van Kerm (2004) refers to a problem that different sequences of eliminating factors from the total mobility measure result in different component contributions. While each computation represents the marginal impact of each factor, they do not sum up to the total mobility computed. In order to derive additive components, Van Kerm proposed to use the Shapley decomposition procedure [see Shorrocks (2013, based on a previous version from 1999) for a comprehensive presentation]; this procedure averages the contributions computed by applying each possible sequence of elimination. In the specific case of a hierarchical decomposition (as in the case here, where the total change is first decomposed to indicate 'exchange' and 'structural' component contributions, and the structural component is further decomposed to indicate 'growth' and 'dispersion' component contributions), a variant of the procedure can be used including two steps that represent two hierarchical levels (Van Kerm 2004).

5. Structural and exchange components of neighbourhood change – an illustration

This section of the paper presents an example to illustrate the application of the proposed decomposition method. The illustration refers to a hypothetical urban area which contains 10 neighbourhoods. The socioeconomic status of neighbourhoods is represented by the variable 'neighbourhood average income', measured in absolute terms of an unspecified currency. Each neighbourhood's average income is observed at two time points, which are referred to as initial and final (Table 1, columns 2 and 3 respectively). For convenience, neighbourhoods are listed in an ascending order according to initial average income. During the observation period, neighbourhood average incomes have changed in a number of ways. First, it is evident from the table that neighbourhoods have changed their relative positions; neighbourhoods 1 & 2, for example, which were the poorest initially, were no longer the

poorest at the second observation. In fact, only neighbourhood 6 kept its original position in the distribution. It can be assumed, therefore, that the 'exchange' effect had an important role in neighbourhood socioeconomic changes. As for structural processes, it is also easy to establish that both 'growth' and 'inequality' components contributed to neighbourhood socioeconomic change. Comparing the average incomes over all neighbourhoods at the initial and final time-points (14.5 and 17.4 respectively) indicates an overall income growth of 20%. The effect of income growth has not been evenly spread throughout the distribution of neighbourhood incomes. The higher the position, the larger the increases in average income and thus, the lowest positioned neighbourhood in the second observation (no. 3) was poorer, in absolute terms, than the poorest neighbourhood in the first observation (no.1), and the highest positioned neighbourhood was richer. In the hypothetical case presented here therefore, both 'growth' and 'inequality' factors collectively produced the structural effect on neighbourhood socioeconomic change. The decomposition procedure, as proposed by Van Kerm (2004), will be used to quantify the extent to which each of the factors ('exchange', 'growth/decline' and 'inequality') contributed to neighbourhood change.

The first step is the construction of counterfactual vectors (Table 1). The 'exchange' counterfactual vector (Column 4) presents neighbourhood final incomes that would be observed if neighbourhoods only exchanged positions according to the patterns appearing in the observed data, assuming that neither the growth or decline of incomes occurred, nor changes in inequality among neighbourhoods. In this illustration, the initially lowest-income neighbourhood moved up 3 positions, the initially highest-income neighbourhood ended up being the third from the top, and additional exchanges took place. The (total) 'Structural' counterfactual vector (Column 5) presents incomes that would be observed if all neighbourhoods maintained their initial positions, but their absolute average incomes changed due to both the 'growth/decline' and 'inequality' effects. This vector shows how identical neighbourhood positions within the metropolitan hierarchy entailed different levels of absolute incomes at the end of the period. For example, the highest position was first associated with an absolute average income of 25, but at the second observation with an average income of 33. The 'growth' counterfactual vector (Column 6) reflects an even growth across the distribution; the actual uneven spread of growth is captured by the 'inequality' vector (Column 7) which applies the shape of the final distribution to the vector of initial incomes; it indicates that the 'inequality' effect increased income disparities among neighbourhoods.

Neighbourhood identifier	initial income	final income	Counterfactual vector - 'exchange'	Counterfactual vectors - 'structural'		
				Total	'Growth'	'Inequality'
1	8	11	10	7	9,6	5,8
2	9	12	11	9	10,8	7,5
3	10	7	8	11	12	9,2
4	11	13	13	12	13,2	10,0
5	13	9	9	13	15,6	10,8
6	14	17	14	17	16,8	14,2
7	16	33	25	19	19,2	15,8
8	18	29	21	24	21,6	20,0
9	21	19	16	29	25,2	24,2
10	25	24	18	33	30	27,5

Table 1 Neighbourhood initial and final average incomes and counterfactual vectors associated with exchange and structural effects. The illustration a hypothetical example and not based on actual data.

In order to assess the relative roles of each component, the total amount of change (Table 2 column 2), and the amount of change associated with each counterfactual vector (Table 2 columns 3-6), are quantified by computing Fields and Ok's (1999b) mobility measure. The sums of absolute differences (bottom line) computed with regard to each factor indicate their importance; The exchange factor in this illustration is more important than the structural one (with a marginal contribution of 2.38 compared to 1.57). Among the structural factors, growth is more important, but inequality has still a sizable effect on neighbourhood change.

Neighbourhood identifier	Total change	Change due to exchange factor	Change due to structural factors		
			Total	Growth	Inequality
1	0,32	0,22	0,13	0,18	0,32
2	0,29	0,20	0,00	0,18	0,18
3	0,36	0,22	0,10	0,18	0,09
4	0,17	0,17	0,09	0,18	0,10
5	0,37	0,37	0,00	0,18	0,18
6	0,19	0,00	0,19	0,18	0,01
7	0,72	0,45	0,17	0,18	0,01
8	0,48	0,15	0,29	0,18	0,11
9	0,10	0,27	0,32	0,18	0,14
10	0,04	0,33	0,28	0,18	0,10
Total	**3,03**	2,38	1,57	1,82	1,23

Table 2 Mobility measures computed based on actual data and on each counterfactual vector

By applying a Shapley hierarchical decomposition (Shorrocks 2013) as advised by Van Kerm (2004), relative contributions can be computed. The decomposition is first applied to compute the relative contributions of exchange and structural components (Table 3, upper panel) to total change. The figures indicate that exchange and structural components account for about 63% and 37% of total change, respectively. A second decomposition is applied to compute the relative contributions of the growth and dispersion factors to the structural component (Table 3, lower panel). The growth of income accounts for 69% of the structural component, and inequality accounts for 31%.

	Exchange component	Structural components	Total change
Factors introduced first	2,383	1,570	3,033
Hierarchical decomposition	1,923 63,4%	1,110 36,6%	3,033 100,0%

	Growth component	Inequality component	Total Structural
Factors introduced first	1,823	1,226	1,570
Hierarchical decomposition	1,083 69,0%	0,486 31,0%	1,570 100,0%

Table 3 Relative contributions of exchange and structural components to total change (upper panel) and of growth and dispersion components to the total structural component (lower panel)

A final demonstration refers to the analysis of effects of different factor components on specific neighbourhoods or parts of the distribution. Table 4 replicates Table 2 using Fields and Ok's mobility measure in non-absolute values. Thus, positive or negative signs are assigned to each case such that the direction of change can be inferred. With regard to the exchange factor (column 1), the array of measures shows that the richest and poorest neighbourhoods moved down and up, respectively, as expected according to the life-cycle model. Measures that correspond to the 'growth' effect are all identical because the counterfactual vector reflects even growth across the distribution. The array of measures related to the 'inequality' factor depicts a typical pattern of increasing inequality; upward change at the top of the distribution and downward change at the bottom. It should be mentioned again, however, that because the counterfactual vector is based on re-ranking, the row contributions do not apply to the specific neighbourhoods identified as 1-10 but rather to positions 1-10 in increasing order. The accurate interpretation is that lower-income neighbourhoods in the final observation were doing worse than those observed at the initial point. The opposite applies for higher-income neighbourhoods, which were richer at the final observation. Because exchange processes are usually not so dramatic (a reversal of socioeconomic positions should take many decades), low-income neighbourhoods are expected to change positions among themselves, and so do high-income neighbourhoods (in the example presented here the five lowest- and highest-income neighbourhoods kept the five lowest and highest positions respectively). In that case, conclusions related to neighbourhood positions can be projected to particular neighbourhoods. In examining the local contributions to both the 'exchange' and 'inequality' factors, the opposite signs at the extreme parts of the distribution indicate how increasing inequality might offset the pattern of mean reversion if its effect is not isolated.

Neighbourhood identifier/position	Change due to exchange factor	Change due to structural factors	
		Growth	Inequality
1	0,22	0,18	-0,32
2	0,20	0,18	-0,18
3	-0,22	0,18	-0,09
4	0,17	0,18	-0,10
5	-0,37	0,18	-0,18
6	0,00	0,18	0,01
7	0,45	0,18	-0,01
8	0,15	0,18	0,11
9	-0,27	0,18	0,14
10	-0,33	0,18	0,10

Table 4 Mobility measures computed based on each counterfactual vector, using the directional measure of Fields and Ok (1999)

6. Discussion

This paper presents a new application to the measurement of neighbourhood socioeconomic change. The application makes a distinction between the contributions of different processes that drive these changes; we classify them as 'exchange' and 'structural' processes. Exchange processes refer to urban-level dynamics that generate mobility of different income strata among neighbourhoods, and consequently change their statuses relative to other neighbourhoods in the urban area. Those dynamics may be associated with the continuously evolving state of the housing stock, as stressed in urban 'filtering' (Muth 1973; Sweeney

1974a, 1974b) and 'life-cycle' (Hoover and Vernon 1959) models. In contrast, structural processes operate at regional, national and global levels, and change neighbourhoods by affecting the socioeconomic characteristics of people that live in the respective urban area. This includes overall income growth or decline that can translate into the growth or decline of the average income of neighbourhoods (Andersson and Hedman 2016; Galster et al. 2003; Zwiers, Bolt, et al. 2016), and also changes in the inequality among individuals that can translate into changing inequality among neighbourhoods.

To date, most studies of neighbourhood change have focused on urban-level processes as drivers of neighbourhood change. This is reflected in the measurement of neighbourhood statuses as relative to other neighbourhoods in the respective urban area (Choldin et al. 1980; Choldin and Hanson 1982; Delmelle 2015; Fogarty 1977; Gould Ellen and O'Regan 2008; Landis 2016; Logan and Schneider 1981; Owens 2012; Rosenthal 2008; Rosenthal and Ross 2015). Relative measures neutralize the effect of overall growth or decline, such that the 'real' extent of change in neighbourhoods' conditions is overlooked. Thus, we currently do not know how substantial structural processes are in changing neighbourhood realities. The common justification for using relative measures is that they leave out processes that operate beyond the urban level (Logan and Schneider 1981). However, the most commonly used relative measure does actually take account of changing inequality, which is considered a structural process that operates at higher levels. Thus, apart from systematically neglecting a possibly important amount of change experienced by neighbourhoods, research to date often confounded the effect of urban-level 'exchange' processes with structural 'inequality' processes. In studies that focus on urban models of change, this can result in attributing a certain amount of change that results from inequality changes to urban dynamics. The illustration brought in section 5 of this paper demonstrates exactly how these two processes may counteract each other and lead to biased results, reflecting an inconsistency of research designs with the theoretical models. This practice also covers up the role of changes in overall inequality in changing neighbourhood socioeconomic conditions. This paper identifies, therefore, the need for a revised approach in the measurement of neighbourhood change. An approach that on the one hand, will enable to take account for the overall amount of change in neighbourhood socioeconomic conditions, and on the other hand, will enable to make a distinction between the different contributing processes.

The proposed approach is based on the distinction among similar process components in social and income mobility research. This paper reviews several methods that deal with decomposing total mobility (or total change) measures into the contributions of factor components, and evaluates their applicability in the context of neighbourhood change research. The paper points to the advantages of a method presented by Van Kerm (2004) which can be applied to various mobility measures. The decomposition enables the comparative analysis of neighbourhood change using absolute income values to represent neighbourhood socioeconomic statuses. This approach thus provides an all-inclusive depiction of neighbourhood change, while still allowing for inter-regional or inter-temporal comparisons.

By applying Van Kerm's decomposition to two different variants of a measure of mobility suggested by Fields and Ok (1999b) the presented approach involves two levels of analysis which may provide complementary insights in the context of neighbourhood change. The first level of analysis is the 'system' or 'global' level which refers to the urban or metropolitan area as a whole. At this level, the total amount of change occurring among metropolitan neighbourhoods is decomposed to reflect the amount of change that can be attributed to the 'exchange', 'growth/decline' and 'inequality' effects, generating a set of system

characteristics. While the use of system descriptive measures is very common in the income mobility literature, this is not the case in neighbourhood change research. Single characteristic measures indeed have the disadvantage of 'flattening' the complexity and diversity of change processes. On the other hand, such measures are useful in a comparative context. Thus, in proposing the application of decomposition methods, this paper not only introduces a practical solution to the problem of distinguishing between components of change, but also promotes the use of 'system-level' measures of neighbourhood change that reflect the characteristics of urban areas as a whole. With regard to this contribution, it should be noted that the computation of such measures is the prevalent practice in segregation research. The second level of analysis looks at the effect of different factor components from a 'local' perspective; it examines how the different components of change affect different parts of the distribution of neighbourhood incomes, different neighbourhood types or neighbourhoods located at different places.

Finally, by using the proposed method to account for exchange and structural processes in neighbourhood socioeconomic change, empirical studies will be able to disentangle the complexity often observed among single urban areas and across them. As most cities struggle with changing disparities among neighbourhoods, and with evolving spatial patterns of these disparities, questions often arise regarding the underlying dynamics; for example, is gentrification of inner city areas merely a changing centre of gravity, or is it a result of the whole city becoming wealthier? Is increasing poverty incidence among peripheral neighbourhoods related to the relocation of the poor due to a cycle of urban development or is it related to changing overall inequality? Answers for such questions can only be sought after by accounting for *all* underlying processes and by making a *distinction* among them. This new insight into neighbourhood socioeconomic change can guide further research and policies that aim to deal with decline and changing spatial disparities.

Disclaimer: This paper reflects the authors' view and the Commission is not responsible for any use that may be made of the information it contains.

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