ASSESSING THE DEGREE OF TERRITORIAL EMBEDDEDNESS AMONG POPULATION SUBGROUPS: A FIRST PROPOSAL[1]

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Abstract. In studies examining the settlement patterns of foreign communities within a region, the primary aim often involves assessing the level of spatial segregation compared to the native population. However, such analyses typically overlook the assessment of the historical presence of these communities in the region. Particularly with small-sized communities, their long-standing presence in the region becomes a significant factor in characterizing both the community and the region itself. This permanence can be seen as a form of embeddedness. It's important to note that the duration of a subgroup's presence in the population may not align with the individual members' length of stay. In some cases, while individual members may have short stays, the community as a whole may maintain a consistent presence over time due to ongoing turnover. To address this aspect, we propose an index that measures the permanence of a population subgroup within a region over a specified time interval, relying solely on its total balance, observed during that period. This index could serve as a straightforward measure of population stability or rootedness, capturing only the overall gains or losses (in terms of time) within the subgroup rather than focusing on the separate contribution of births, deaths, immigration, and emigration. This index is complemented by the evaluation of its uncertainty, by assuming the goodness of the indicator is based on the stationarity of the historical series of values computed on the sub-periods. To support the utility of this index, we apply it to population subgroups categorized by citizenship in the Metropolitan Area of Milan.

1. Introduction

In studies examining the settlement patterns of foreign populations within a region, the primary aim often involves assessing the level of spatial segregation compared to the native population. Research in this field is abundant, covering both the development of measures, (among the first, Hoover, 1941; Duncan and Duncan, 1955; Isard, 1960) and their applications (among the latest referring to the Italian context, Bitonti *et al.*, 2023; Conti *et al.*, 2023; Pratschke and Benassi, 2024; Rimoldi *et al.*, 2024). However, such analyses typically overlook the assessment of the historical presence of these populations in the region. A population group's enduring

[1] Sections 1 and 3 are written by Federico Benassi, sections 2 and 4 are written by Stefania Rimoldi.

presence indicates its embeddedness in the area, influencing individual behaviours and affecting the dynamics of segregation and socio-economic transformation within those spaces (Logan *et al.*, 2002; Massey and Denton, 2019; Sensenbrenner and Portes, 2018). For migrant groups, territorial embeddedness can occur as they establish roots in a new location, creating a 'home away from home.' In cities with a high influx of migrants, certain neighbourhoods might become known for their association with specific ethnic or cultural groups. This process allows migrants to preserve their cultural identity and adapt to their new setting. However, it can also pose challenges if territorial embeddedness leads to social isolation or limited integration with the broader community. One important note is that the duration of a group's presence in a territory may not align with the length of stay of individual members. In some cases, while individual members may have short stays, the group as a whole may maintain a consistent presence over time due to ongoing turnover. This is particularly evident in the case of foreign populations, which are often characterised by high variability, with significant fluctuations in inflows and outflows, especially in small areas. This article aims to propose a method for measuring the dynamics of population group permanence within a given territory over a given time interval. The indicator introduced in this study can serve as a complementary measure in population change research, that addresses the role and impact of the different demographic components on demographic shifts (Billari, 2022; Plane and Rogerson, 1994; Rees *et al.*, 2017; Rogerson and Bagchi-Sen, 2023). The focus is to measure the degree of embeddedness of a specific population subgroup within a particular territory, observed over a defined time interval, irrespective of the dynamics of individual components. Being based on the total balance, and considering the cumulative years lived in the area by the subgroup's annual net flows over the period, this indicator helps to shed light on the dynamic of a population group in a given area. Although the application provided here is demonstrated with population groups by country of citizenship, it is also applicable to subgroups defined according to other classification characteristics.

The paper is structured as follows: section 2 is devoted to the methodological construction of the indicator, then section 3 presents its application, and finally, section 4 discusses the limitations and concludes the paper.

2. The indicator of territorial embeddedness

Let *X* the group of the population, *i* the area ($i = 1, \dots, r$), *t* the order number of years $t = 1, \dots, n$, with $n>1$, and *P(X)* the population of group *X*, on 1st January of the years *t*, the total balance of population in each year *t* is:

$$B_i^t(X) = P_i^{1.1.t+1}(X) - P_i^{1.1.t}(X) \quad (1)$$

Hereafter, we use B^t for $B_i^t(X)$, to simplify the notation.

Under the hypothesis of uniform distribution of flows (births, deaths, immigrations, emigrations and Italian citizenship acquisitions and losses) during each year, we assume that the contribution of each yearly demographic balance in the period $[1; n]$ is:

$$s^t = n - t + 0.5 \quad (2)$$

Then, the total amount of years lived (hereafter YL) by the group X during the period $[1; n]$ is:

$$YL = \sum_{t=1}^{n} B^t \cdot s^t \quad (3)$$

Finally, the average time spent (average years lived, AYL) by the total balance of the group X during the period $[1; n]$ is:

$$AYL = \frac{YL}{\sum_{t=1}^{n} |B^t|} \quad (4)$$

Notice that the total amount of years (3) can be either positive or negative. AYL is indeterminate when $B^t = 0$ for any $t = 1, \dots, n$. In this special case we assume that the permanence of the group in the area is zero, which corresponds to a neutral situation with respect to increasing or decreasing embeddedness. Moreover, $B^t = 0$ for any $t = 1, \dots, n$ corresponds both to null inflows and outflows and compensative flows. This does not influence the average dynamics of the embeddedness of the group in the territory.

The AYL (4) can be made independent from the length of the period examined, by computing the per-year average dynamics of embeddedness:

$$\overline{AYL} = \frac{AYL}{n - 0.5} \quad (5)$$

The $\overline{AYL}$ varies in the interval $[-1; +1]$. It assumes the maximum value (+1) when $\sum_{t=1}^{n} B^t = \sum_{t=1}^{n} |B^t|$ and $B^t = 0 \; \forall \; t = 2, \dots, n$; $B^1 > 0$, while conversely it assumes the minimum value (-1) when $\sum_{t=1}^{n} B^t = -\sum_{t=1}^{n} |B^t|$ and $B^t = 0 \; \forall \; t = 2, \dots, n$; $B^1 < 0$ (see the toy example in Table 1). The maximum value (+1) indicates full embeddedness, that is a stable presence overtime, while conversely, the minimum value (-1) indicates full disembeddedness, meaning that the population *X* left from the area permanently during the interval $t = 1, \dots, n$.

Table 1 – *Toy example: n=10,* $\sum_{t=1}^{n} |B^t| = 100$*, and the two extreme situations corresponding to: (a) positive balance; (b) negative balance.*

		(a) Positive balance		(b) Negative balance	
t	s^t	B^t	YL	B^t	YL
1	9.5	100	950	-100	-950
2	8.5	0	0	0	0
3	7.5	0	0	0	0
4	6.5	0	0	0	0
5	5.5	0	0	0	0
6	4.5	0	0	0	0
7	3.5	0	0	0	0
8	2.5	0	0	0	0
9	1.5	0	0	0	0
10	0.5	0	0	0	0
		$\sum_{t=1}^{n} \lvert B^t \rvert$=100	$\overline{AYL} = 1$	$\sum_{t=1}^{n} \lvert B^t \rvert$=100	$\overline{AYL} = -1$

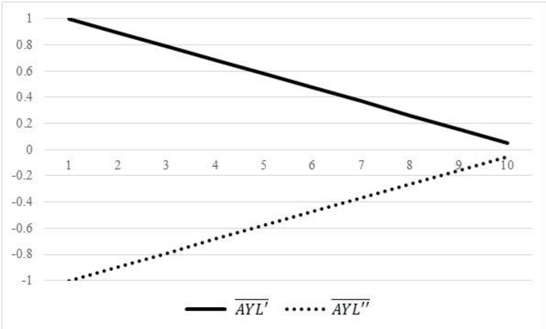
The maximum and minimum circumstances help to shed light on the behaviour of $\overline{AYL}$ overtime. Indeed, when the total amount of balances $\sum_{t=1}^{n} |B^t|$ occurs in just one year *t* of the period, $\overline{AYL}$ is expressed by the following linear equations (6), and illustrated in Figure 1 with reference to the toy example of Table 1.

$$\begin{cases} \overline{AYL'} = -\dfrac{1}{n-0.5} \cdot t + \dfrac{n+0.5}{n-0.5} \quad (\mathrm{t} = 1, \dots, \mathrm{n}) \\ \text{if } \displaystyle\sum_{t=1}^{n} B^t = \sum_{t=1}^{n} |B^t| \text{ and } B^t = 0 \ \forall \text{ t except one} > 0 \\ \overline{AYL''} = \dfrac{1}{n-0.5} \cdot t - \dfrac{n+0.5}{n-0.5} \quad (\mathrm{t} = 1, \dots, \mathrm{n}) \\ \text{if } \displaystyle\sum_{t=1}^{n} B^t = -\sum_{t=1}^{n} |B^t| \text{ and } B^t = 0 \ \forall \text{ t except one} < 0 \end{cases} \tag{6}$$

From Figure 1 it emerges that the indicator proposed is coherent with its meaning: it decreases approaching zero when the total balance occurs in the most recent years, compared to the reference year of the indicator, signalling low embeddedness of *X* if positive, and low disembeddedness if negative, while conversely it increases up to

1 (or -1) when the total balance occurs in the most distant years of the interval, showing a high stable embeddedness (if positive) or disembeddedness (if negative).

Figure 1 – *Toy example:* $\boldsymbol{n=10}, \sum_{t=1}^{n}|\boldsymbol{B^t}| = \pm\mathbf{100}$ *,* $\overline{\boldsymbol{AYL'}}$ *and* $\overline{\boldsymbol{AYL''}}$ *computed as in (6).*



2.1. Evaluation of the reliability of the indicator

The implicit question when calculating $\overline{AYL}$ is: "Is the value obtained reliable?"

A first consideration refers to the length of the interval, *n*. We theoretically can suppose that the greater is *n*, the more reliable is $\overline{AYL}$. This consideration can serve as a starting point for the empirical strategy we chose. Thus, we imagine period *n* being broken up into sub-periods, and $\overline{AYL}$ is calculated for all the possible n-2 sub-periods (with at least 2 balances), starting from the most recent year: $k = [n; n-2], [n; n-3], \ldots, [n, 2]$.[2] We assume the goodness of indicator be based on the assumption of stationarity of the historical series of $\overline{AYL}_k$. We test the stationarity with the Dickey–Fuller Test (1979), to test whether the variable follows a random walk. The null hypothesis is that the variable follows a random walk. The Test provides results for the three critical values 0.01, 0.05, and 0.1.

2.2. Alternative strategy: the location quotient of embeddedness

It is essential to note that stationarity is not always a valid assumption, particularly in dynamic or evolving systems where trends, cycles, or structural breaks may occur. An alternative strategy consists in comparing the index computed with reference to the specific population group *X* to the total population *P*, or to another group *Y*. Considering the groups by country of citizenship, for example, we may be

[2] Notice that $\overline{AYL}_k$ with $k = [n, 1]$, gives the $\overline{AYL}$

interested to compare the intensity of embeddedness of group *X* in a certain territory (relative to its average embeddedness in the entire region), with the same indicator computed for total population *P*. To do this, it is first necessary to apply the min/max procedure to the index so that it varies between 0 and 1:

$$\overline{\overline{AYL}} = \frac{\overline{AYL} - (-1)}{1 - (-1)} = \frac{\overline{AYL} + 1}{2} \tag{7}$$

with $\overline{\overline{AYL}} \in (0.5;1]$ indicating embeddedness, $\overline{\overline{AYL}} \in [0;0.5)$ indicating disembeddedness, and $\overline{\overline{AYL}}=0.5$ indicating the case when $B^t = 0 \; \forall \; \mathrm{t} = 1, \dots, \mathrm{n}$, (the AYL is indeterminate), where we assume that the embeddedness of the group in the area is zero, which corresponds to a neutral situation with respect to increasing or decreasing embeddedness.

Then, in analogy to the calculus of the Location Quotients (Isard, 1960), given the group *X* of the population *P*, in each sub-area *i* of the region *R*, we can compare the ratio between the embeddedness of *X* in *i*, $\overline{\overline{AYL}}_i(X)$, and the embeddedness of total population *P* in *i*, $\overline{\overline{AYL}}_i(P)$, with the ratio between the average embeddedness of *X* in *R*, $\overline{\overline{AYL}}_R(X)$, and the average embeddedness of *P* in *R*, $\overline{\overline{AYL}}_R(P)$, deriving the following relative measure of location quotient of embeddedness:

$$ELQ_i^{X/P} = \frac{\overline{\overline{AYL}}_i(X) / \overline{\overline{AYL}}_i(P)}{\overline{\overline{AYL}}_R(X) / \overline{\overline{AYL}}_R(P)} \tag{8}$$

The interpretation of the ELQ is analogous to the interpretation of the LQ; it provides a measure of comparison between the embeddedness of the group *X* relative to *P* in the sub-region *i*, compared to the embeddedness of group *X* relative to *P* in the whole region *R*.

3. Empirical applications

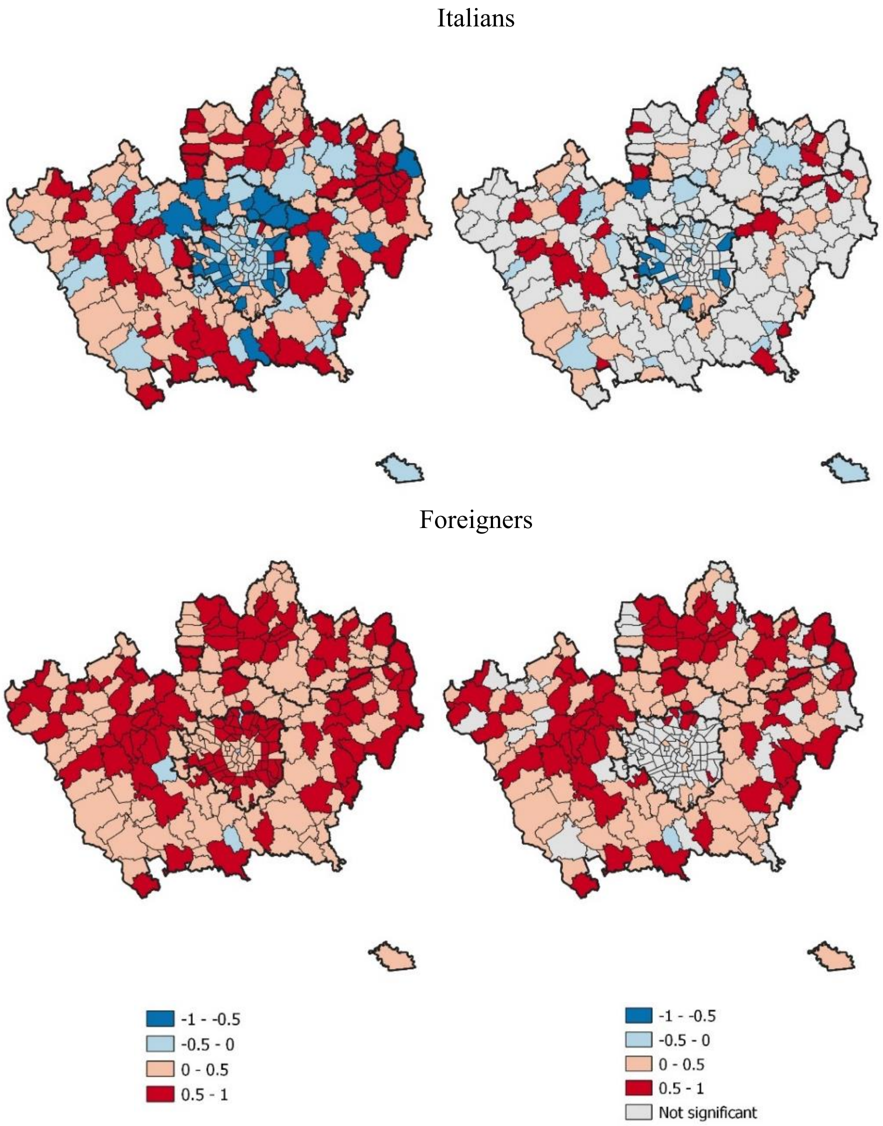
Solely for the purpose of illustrating the performance of the indicator, we propose the following application, where we use the total population on 1st January of the years 2004–2022 by country of citizenship, Italians and foreigners. The geographical setting analysed is the Metropolitan Area of Milan, i.e. the province of Milan, with the addition of the municipalities of the province of Monza-Brianza (formerly to 2009 included in the province of Milan). The city of Milan is subdivided in the 88 administrative neighbourhood called NIL (Nuclei di Identità Locale). The indicator was also tested using the Dickey–Fuller Test, with a critical value set at 0.1. Regarding the critical value of the test, we opted for the most inclusive value concerning the time series stability. Table 2 provides the results of the test for the three critical values.

Table 2 – *Dickey-Fuller Test for $\overline{\boldsymbol{AYL}}$: number of significant values by critical values, for Italians and foreigners.*

	Critical values			Total
	0.01	0.05	0.1	
Italians	79	17	12	108
Foreigners	133	20	11	164

Figure 2 (left side) highlights how, during the period from 2004 to 2022, the historical centre of Milan was characterised by disembeddedness for both populations. Italians (upper panel) show the highest level of embeddedness in the most peripheral municipalities of the metropolitan area and the highest levels of disembeddedness in the city and in the contiguous northern municipalities. However, these results show little reliability (upper panel, right side), except for the following cases. We find a high level of embeddedness (0.5 – 1] in: the NlL of *Muggiano*, showing the highest level of embeddedness (0.72), the cluster of municipalities in the north-western direction (composed of *Cisliano*, *Corbetta, Marcallo con Casone, Mesero,* and *Santo Stefano Ticino*) −this area, known as Parco del Gelso, is mainly characterised by agricultural activity−, the small cluster of *Cernusco S.N.* and *Vimodrone*, north-eastern municipalities contiguous to Milan, and some municipalities in the province of Monza-Brianza, like *Corezzana*, *Sulbiate*, and *Sovico*. A moderate (0 – 0.5] embeddedness is observed in the cluster of territorial units composed of peripheral contiguous southern NILs in the city, such as *Quintosole, Stadera, Cantalupa, Parco delle Abbazie*, and *Parco dei Navigli*, and municipalities (*Buccinasco, Opera*, and *Trezzano S.N.*). Conversely, a relatively high level of disembeddedness (-1 – -0.5) is observed in some peripheral NILs all around the city, such as *Ortomercato* (-0.58), *Baggio, Parco Lambro and Gallaratese* (-0.57), *Mecenate and Trenno* (-0.54), *Gratosoglio, Giambellino and Forze Armate* (-0.53), and *Quinto Romano (-0.51).*

Figure 2 – $\overline{\boldsymbol{AYL}}$ *(left side) and* $\overline{\boldsymbol{AYL}}$ *filtered with the Dickey–Fuller Test (right side), for Italians and foreign citizens, in the Milan MA, 2004-2022.*



Foreigners (lower panel) exhibit positive embeddedness almost everywhere, particularly high (0.5–1) in the city outside the historical centre (left side), though not significantly stable (right side). The main areas of higher stable embeddedness are: 18 contiguous municipalities in the western part of the metropolitan area −a large industrial area stretching from *Gaggiano* in the south to *Cerro Maggiore* in the north−, 16 contiguous municipalities, all in the province of Monza-Brianza (except for *Paderno D.*) −including *Desio, Cesano M.*, *Carate B.*, up to *Lentate S.S.*, known as the "Distretto del mobile della Brianza" −, a small cluster of four municipalities in the province of Monza-Brianza around *Vimercate*, and 5 contiguous municipalities at the border of the province of Milan with the province of Bergamo, including *Trezzo sull'Adda* and *Cornate d'Adda*.

Figure 3 – *ELQ for foreigners (total population as reference), in the Milan MA, 2004-2022.*

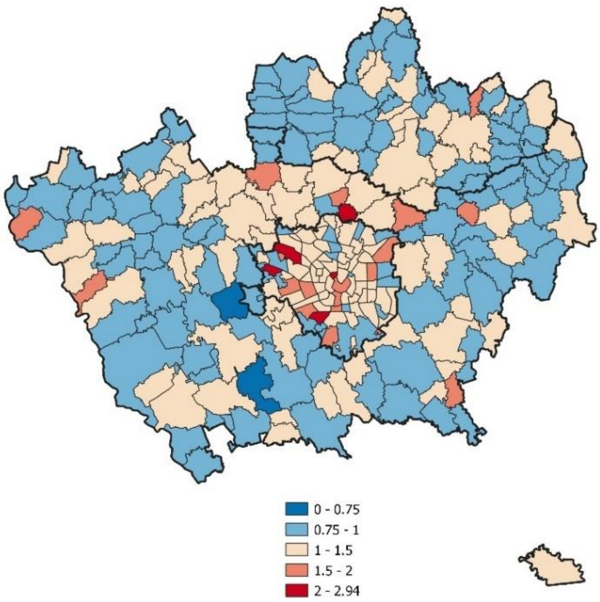


Figure 3 shows the results of $ELQ_i^{X/P}$ for foreigners, with reference to the total population P. Overall, the local relative embeddedness of foreigners is markedly different from the relative embeddedness of total population in very few areas. It is sensibly low (< 0.75) in only two municipalities, *Cusago* and *Noviglio*, in the western part of the Milan MA, while it is very high (≥ 2) in only the 4 NILs of *Parco Sempione* (2.94)[3], *Barona* (2.49), *Gallaratese* (2.14) and *Quinto Romano* (2.11), and in the municipality of *Bresso* (2.06). High (1-5 – 2.0) intensity of ELQ is found in

[3] Notice that in *Parco Sempione* population is reported as 1 to 3 units, during the period.

few NILs (*Duomo, Ticinese* and *Tibaldi* in the historic centre, *Gratosoglio* and *Ronchetto S.N.* in the south, *Bande Nere* and *Forze Armate* in the west, and finally, *Parco Lambro* and *Città Studi* in the east), and in sparse municipalities, such as *Cologno Monzese* and *Cusano Milanino* near the city border, *Garbagnate M.* in the north, *Turbigo* and *Boffalora T.* in the west, and finally *Bussero* and *Carnate* (the only one in the province of Monza- Brianza) in the north-east. Finally, a large stream of contiguous municipalities in the north is characterised by moderate (1 – 1.5) intensity of ELQ.

4. Discussion and conclusions

In this paper, we propose a new index for evaluating the dynamics of the permanence of a population group within a given territory over a specified time period. The index $\overline{AYL}$ is intended to convey the meaning of embeddedness in the territory, whereby the stable presence of a community contributes to defining local identity by reflecting the interaction between social and physical factors. These identities significantly influence how specific neighbourhoods are perceived as desirable places to reside and settle (Robertson *et al.*, 2010). Based exclusively on yearly total balances, the index includes all types of dynamics—natural, migratory, and administrative. The latter is particularly relevant for migrants who may acquire the citizenship of the host country during the period of observation, thus representing a flow. Overall, for the purposes of the index, the distinction between natural and migratory balances is not relevant, as the concept of embeddedness of a population group can derive from both. Conversely, flows resulting from changes in citizenship status should be carefully managed, when relevant (i.e. when dealing with national contexts), due to their impact on the concept of the group's embeddedness. Also at a local level, anyway, the effect of changes in citizenship status can be relevant and constitute a limitation of the index, in this form. Intuitively, a possible solution could involve applying a corrective factor based on the difference between residents by citizenship and by country of birth, data recently made available by the National Institute of Statistics (Istat) at the municipal level.

Moreover, as mentioned in the introduction, the duration of a group's presence in a territory may not align with the length of stay of individual members. Individual members may have short stays, yet the group as a whole can maintain a consistent presence over time due to ongoing turnover. In summary, since the index measures the average time spent by the yearly net balances of the population group during the period, the length of the period n, becomes a primary concern. It is desirable for n to be sufficiently long to give meaning to the concept of embeddedness. However, a period that is too long may encompass contextual events (such as years of economic recession) that can temporarily but significantly alter the dynamics of the balances. This eventuality also impacts the stationarity of the historical series of values of the indicator, for which a test is proposed. Beyond the knowledge of the general context, then, a preliminary analysis of the trend of balances is unavoidable, and a series of indices computed for sub-periods can be useful to evaluate the overall dynamics.

Further limitations can derive from the size of the group and of the territory. Although the index is independent of the population size, as it is based solely on annual balances, a primary consideration is the appropriateness of computing such an index for very small populations and very small territories. Secondly, the gravitational effects of larger populations on the territory and their growth rate should be considered. In our application, focusing on Italians, we explored these relationships through simple correlations. Both the correlations between the index and the average population, and between the index and the average annual growth rate, resulted in negligible negative values.

These and other aspects of the index will be treated and experimented on other populations and contexts in next research.

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