Can Spatial Diffusion Process explain Family Changes? An Analysis of Non-Marital Births over 50 years in Belgium

Background

The Second Demographic Transition (SDT) is one of the most prominent framework explaining the family changes witnessed across many countries in Europe since the 1960s. The proponents of the SDT suggests that shifts in individual values and ideation, especially among secular, urban, and educated populations, drive new family behaviours like cohabitation, non-marital births, divorce (Lesthaeghe & Van de Kaa, 1986). However, SDT has faced criticism for its limited scope (Zaidi & Morgan, 2017), particularly for not incorporating economic and gender perspectives. Alternative frameworks, such as the *Pattern of Disadvantage* (Perelli-Harris et al., 2010) and the *New Home Economics* (Becker, 1981), highlight the role of economic insecurity, unemployment, and women's increased labour market participation in shaping family dynamics. These frameworks argue that family changes result from complex interactions among cultural, economic, and social factors rather than a single cause.

The evolution of family changes has shown significant regional and temporal variation influenced by cultural, economic, and policy changes (Esteve & Lesthaeghe, 2016; Kiernan, 2001; Klüsener, 2015; Ruggles, 2015; Shorter et al., 1971). However, in the extensive literature on family change, the geographical dimension remains the least explored. It is important to see how family changes are spread geographically, because it can provide crucial elements in the theoretical debate about family changes. Several studies have taken a spatiotemporal approach to study how the changes in the family behaviours are spread across space and time (Bleha & Ďurček, 2019; Caltabiano et al., 2019; Doignon, 2021; Doignon et al., 2020; Vitali et al., 2015). They showed that these changes are not random and follow a structured spatial diffusion process, influenced by geographical proximity and urban hierarchy, with urban areas often being the leading regions. However, with exceptions, this type of study has remained mainly descriptive. We still have a lot to learn about explaining the spatial dynamics of family changes, for example, whether these spatial diffusions are in fact due to other underlying factors.

Thus, in this article we aim to answer 2 research questions: (1) investigate whether the spatial dynamics of family changes can be explained solely by socio-economic factors, or whether there is also a spatial diffusion effect, and (2) to analyse which explanatory dimension(s) is/are most relevant to explain these spatial dynamics over time. To our knowledge, we could not find any study that explains in detail the spatial diffusion process and articulates the determining factors over time. To answer this question, we decided to analyse the spatial diffusion of non-marital births. The rise in non-marital births is considered as one of the most significant family changes (Perelli-Harris et al., 2012). They showed a steady increase since the late 1960s across Europe. After that, the incidence of non-marital births began rising sharply, with countries in Northern Europe experiencing particularly high rates. By the mid to late seventies, rates had also begun to increase in most countries of Central and Western Europe. The development was more delayed in Southern European countries (Klüsener, 2015; Mack, 2017). By 2018, 42% of the births in most European countries were outside marriage. This contrasts sharply with earlier norms that positioned marriage as a prerequisite for family formation and childbearing (Perelli-Harris et al., 2012). Belgium is one of the countries in North-Western Europe where the increase in non-marital birth started after the 1980s. Until 1987, the prevalence of non-marital birth in Belgium was less than 10%, which reached 50% in 2017. This is a rapid transition as it took place in just 30 years. Moreover, it is among the first countries where SDT and the spatial dynamics of some family changes have already been studied (Doignon et al., 2020; Lesthaeghe & Neels, 2002). However, very little is evidenced on the spatial dynamics of non-marital births in Belgium. Moreover, we could not find evidence from any study that used data from the point when the diffusion process started. Belgium has a long tradition of producing statistics at municipal-level, which allows us to study spatial diffusion in detail (high spatial and temporal accuracy). Thus, Belgium provides an important study area as it meets all the methodological conditions set above. Moreover, the Belgian data allows us to study the spatial dynamics of family changes in a way which has never been done before, thus maintaining the originality of our research (i.e. both thematic and methodological).

Data and Methods

Belgium has a rich history of detailed statistical recording, but no accessible municipal-level database exists for our research covering the period from the 1960s onward. To address this, we compiled data from numerous sources and periods (Table 1), digitizing old records and harmonizing them to account for administrative changes, such as the reduction of municipalities from 2,359 to 589 between 1968 and 1983. We created a unique database covering 1968-2017, converting all data to a consistent 589-municipality framework and using interpolation and aggregation to standardize variables across different periods. This comprehensive database enables an in-depth analysis of non-marital births at the municipal level over 50 years, a rare resource in existing literature.

Variable	Indicator	Data sources
Non-marital births	Share of non-marital births (%)	Civil registry/National Register
Secularisation index	Share of the votes for the Socialist, Communist and Liberal parties in parliamentary elections (%)	Federal Public Service of the Interior (IBZ)
Urbanisation	Population density = number of inhabitants / area	Population censuses/National Register
Population with higher education	Share of the population aged 15 and older who achieved high education (%)	Population censuses
Unemployment	Share of the unemployed men aged 15-64 (%)	National Employment Office (ONEM)
Population structure	Population aged 65 and older / population aged 15-64 (%)	Population censuses/National Register
Sex-ratio of labour market participation	Economic activity rate of women (15-64) / Economic activity rate of men (15-64)	Population censuses
Foreign population	Share of the population without Belgian nationality (%)	Population censuses/National Register

Using a series of maps, we illustrate the evolution and spatial diffusion of non-marital births in Belgium from 1968 to 2017. Initially low across most municipalities, non-marital birth rates began increasing in the late 1970s, particularly in secularized, industrial regions like Wallonia and the Brussels area, and later spread to conservative regions like Limbourg or the two Flanders. By 2013-2017, high rates were observed mainly in rural areas, reversing the earlier urban-rural trend. Spatial autocorrelation analysis using Moran's I showed increasing clustering of high non-marital birth rates over time, supporting a diffusion process.

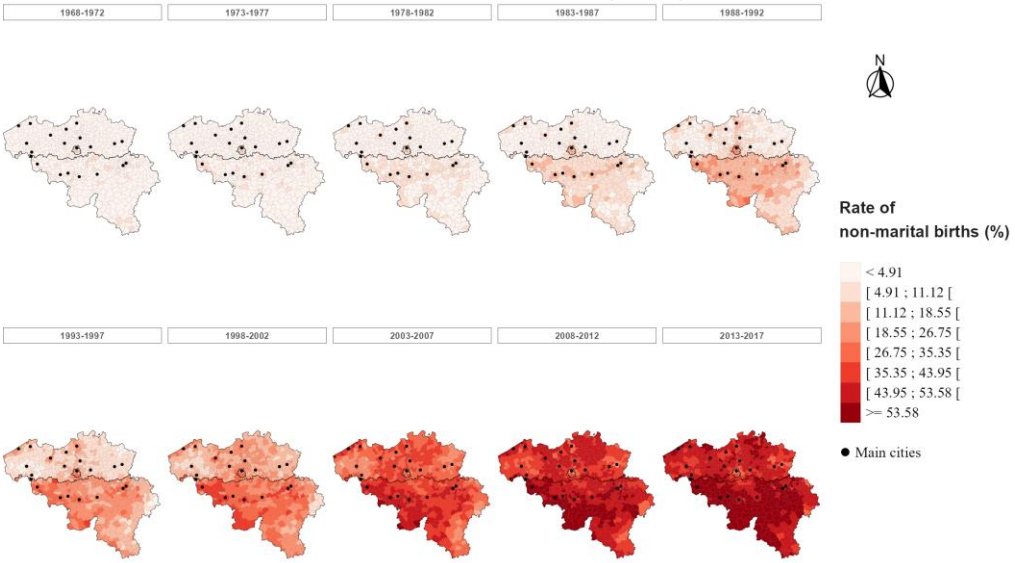


Fig 1: Non-Marital Births in Belgium (1968-2017)

Thus, we see a diffusion process in the increase in non-marital births. Non-marital birth rates in a given municipality seem to be influenced by the rates in neighbouring municipalities, where areas are more likely to see an increase in non-marital births if nearby regions have already seen an increase in the phenomena. To consider these different elements in our analyses, we decided to use spatial modelling. We have used two types of analytical approaches, one for each research question. The first is the Dynamic Spatial Durbin Model (DSDM) to measure the spatial diffusion effect. The second is the estimation of several Spatial Durbin Models (SDM) to assess the evolution over time of the main determinants of the spatial dynamics of the non-marital births. The Dynamic Spatial Durbin Model (DSDM), an extension of the Spatial Panel Durbin Model, considers the effect of the spatial and temporal lag on both the dependent and the independent variables. For a given region, the spatial-temporal lag is the value of a variable in the neighbouring regions in the previous time-period. This means that its own characteristics and those of neighbouring regions model the level of non-marital births in a region. The DSDM represents an advanced framework for comprehensively analysing the spatial dynamics of non-marital births in Belgium and answer our 1st research question. However, there are several reasons why we can no longer use this model to answer our 2nd research question. In a panel model, the parameters are an average effect over all periods.

This average effect may hide different effects of a variable over different periods. This does not allow us to identify the changing effect of the explanatory variables on non-marital births over time. For instance, the model cannot measure whether unemployment or secularisation has the same effect on non-marital births over time, or whether the effect is higher or lower in one period than in others. Thus, we use an approach involving ten different Spatial Durbin Models, each corresponding to a specific period, with exactly the same variables in each model. This allows us to see how the contribution of various factors in explaining non-marital births in Belgium evolves over time. This methodological arrangement enables a more detailed examination of the temporal variations in the factors that shape the spatial dynamics of non-marital births, thereby increasing the potential for theoretical interpretations of our analytical framework. This methodological approach combining dynamic spatial modelling and variable standardisation for 10 periods offer a robust analysis of the temporal dynamics of the factors affecting non-marital births.

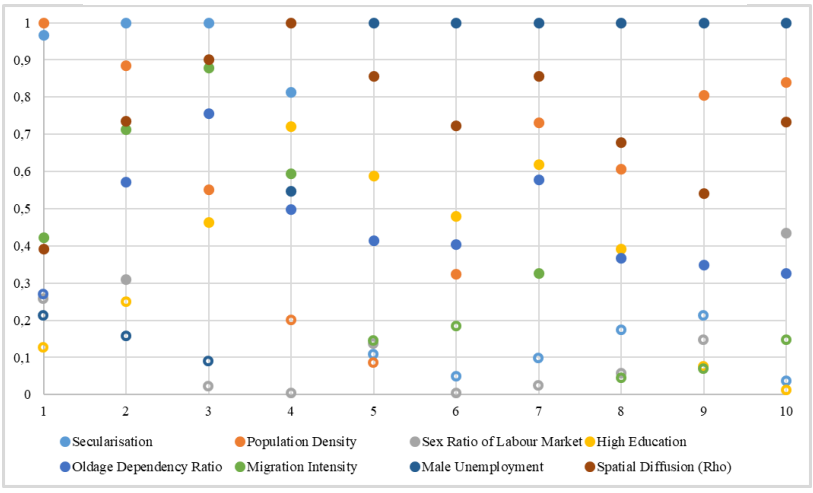
Findings

Our study using the Dynamic Spatial Durbin Model (DSDM) provides evidence of significant spatial and temporal dynamics influencing the rates of non-marital births in Belgium from 1968 to 2017. The strong spatial autocorrelation coefficient ($\rho = 0.57$) suggests substantial clustering, indicating that non-marital births are not randomly distributed but are strongly influenced by the rates in neighbouring municipalities. The significant spatial diffusion effect ($\delta = 0.14$) further supports this, showing that an increase in non-marital births in one municipality is associated with increases in adjacent municipalities over time, underscoring the importance of geographical proximity in the spread of social behaviours. The temporal lag coefficient (0.29) reveals that past non-marital birth rates have a significant and positive influence on current levels, reflecting temporal dependency in these dynamics.

Variables	β Coefficient	p-value	Marginal Effects					
			Impacts directs	p-value	Impacts indirects	p-value	Impacts total	p-value
ρ (WYit)	0.299	0.000						
Spatial diffusion (WYi t-1)	**0.145**	**0.000**						
Time lag (Yi t-1)	0.570	0.000						
Secularization	0.009	0.001	-0.002	0.332	0.016	0.000	0.014	0.000
Sex-ratio of labour market participation	-0.224	0.069	-0.075	0.484	-0.525	0.000	-0.599	0.000
Population density	0.000	0.007	0.000	0.272	-0.001	0.007	0.000	0.016
High education	-0.016	0.023	0.007	0.237	-0.025	0.003	-0.018	0.011
Old-age dependency ratio	1.491	0.002	0.888	0.014	4.030	0.000	4.919	0.000
Migration intensity	-0.003	0.710	0.007	0.274	0.002	0.891	0.009	0.447
Male unemployment rate	-0.007	0.624	0.020	0.091	0.008	0.594	0.028	0.001

Over different periods, the determinants of non-marital births have evolved (fig 2). In the initial phases (1968-1982), secularisation and urbanisation were the strongest factors, highlighting the role of more secular and urban areas in pioneering the spread of non-marital births, consistent with the Second Demographic Transition (SDT). During the 1980s, unemployment emerged as a key determinant, reflecting the *Pattern of Disadvantage*, with regions affected by high unemployment, such as Wallonia, showing higher non-marital birth rates. However, secularisation remained relevant, particularly in regions like the Walloon coalfields, where high unemployment and lower church attendance coincide, indicating a complex interaction between these variables.

Fig 2: Ranking of the factors affecting non-marital births



Spatial diffusion continued to play a critical role throughout all periods, consistently ranking high in effect alongside other factors, suggesting that the spread of non-marital births is shaped by both social proximity and diffusion dynamics. Other factors, such as the proportion of foreigners and higher education, had varying but lesser effects, primarily in the earlier decades. The complex interplay of these determinants, alongside the persistent spatial diffusion effect, highlights that no single theory fully explains the trends in non-marital births in

Belgium. Instead, multiple theories, such as the SDT and the *Pattern of Disadvantage*, combine with spatial diffusion to provide a comprehensive understanding of how socio-economic, cultural, and spatial factors have collectively shaped non-marital birth trends over several decades.

Conclusion

This study is pioneering in its application of the DSDM to measure the spatial diffusion effect of a family change. To our knowledge, no previous research has used this dynamic model to capture the spatial effects of demographic events. By using the DSDM, our study offers novel insights into spatial dynamics of population phenomena. The local geographical level and extended time-period of 50 years employed in this study represent a strong empirical originality. This has allowed us not only to describe and study in detail the spatial diffusion of non-marital births since the beginning of the process, that is rarely done in the literature, but also to identify the factors affecting the spatial diffusion of non-marital births, quantify the magnitude of each variable, and rank them accordingly for different time periods. Thus, our offer a compelling examination of how non-marital births have evolved spatially. Some explanatory variables have influenced the complex spatial landscape of non-marital births. This research significantly advances in our understanding of family changes in Western Europe, with a particular focus on non-marital births.

References

Becker, G. S. (1981). A Treatise on the Family. *Population and Development Review*, *18*(3), 563.

Bleha, B., & Ďurček, P. (2019). An interpretation of the changes in demographic behaviour at a sub-national level using spatial measures in post-socialist countries: A case study of the Czech Republic and Slovakia. *Papers in Regional Science*, *98*(1), 331–352.

Caltabiano, M., Dreassi, E., Rocco, E., & Vignoli, D. (2019). A subregional analysis of family change: The spatial diffusion of one-parent families across Italian municipalities, 1991–2011. *Population, Space and Place*, *25*(4), 1–16. https://doi.org/10.1002/psp.2237

Doignon, Y. (2021). Géographie d'un changement social. La diffusion spatiale des naissances hors mariage en France depuis un demi-siècle. *L'Espace Géographique*, *Tome 49*(3), 213–232. https://doi.org/10.3917/eg.493.0213

Doignon, Y., Eggerickx, T., & Rizzi, E. (2020). The spatial diffusion of nonmarital cohabitation in Belgium over 25 years: Geographic proximity and urban hierarchy. *Demographic Research*, *43*(48), 1413–1428. https://doi.org/10.4054/DemRes.2020.43.48

Esteve, A., & Lesthaeghe, R. J. (2016). Cohabitation and marriage in the Americas: Geo-historical legacies and new trends. In *Cohabitation and Marriage in the Americas: Geo-Historical Legacies and New Trends*. https://doi.org/10.1007/978-3-319-31442-6

Kiernan, K. (2001). The rise of cohabitation and childbearing outside marriage in Western Europe. *International Journal of Law, Policy and the Family*, *15*(1), 1–21.

Klüsener, S. (2015). Spatial variation in non-marital fertility across Europe in the twentieth and twenty-first centuries: recent trends, persistence of the past, and potential future pathways. *History of the Family*, *20*(4), 593–628. https://doi.org/10.1080/1081602X.2015.1099112

Lesthaeghe, R., & Neels, K. (2002). From the first to the second demographic transition: An interpretation of the spatial continuity of demographic innovation in France, Belgium and Switzerland. *European Journal of Population/Revue Européenne de Démographie*, *18*, 325–360.

Lesthaeghe, R., & Van de Kaa, D. J. (1986). Twee demografische transities. *Bevolking: Groei En Krimp*, *1986*, 9–24.

Mack, A. (2017). *Non-marital fertility in Europe: development, parents' socioeconomic resources and social context* (Vol. 16). DEU.

Perelli-Harris, B., Kreyenfeld, M., Sigle-Rushton, W., Keizer, R., Lappegård, T., Jasilioniene, A., Berghammer, C., & Di Giulio, P. (2012). Changes in union status during the transition to parenthood in eleven European countries, 1970s to early 2000s. *Population Studies*, *66*(2), 167–182.

Perelli-Harris, B., Sigle-Rushton, W., Kreyenfeld, M., Lappegård, T., Keizer, R., & Berghammer, C. (2010). The educational gradient of childbearing within cohabitation in Europe. *Population and Development Review*, *36*(4), 775–801.

Ruggles, S. (2015). Patriarchy, power, and pay: The transformation of American families, 1800–2015. *Demography*, *52*(6), 1797–1823.

Shorter, E., Knodel, J., & Van De Walle, E. (1971). The decline of non-marital fertility in Europe, 1880–1940. *Population Studies*, *25*(3), 375–393.

Vitali, A., Aassve, A., & Lappegård, T. (2015). Diffusion of Childbearing Within Cohabitation. *Demography*, *52*(2), 355–377. https://doi.org/10.1007/s13524-015-0380-7

Zaidi, B., & Morgan, S. P. (2017). The Second Demographic Transition Theory: A Review and Appraisal. *Annual Review of Sociology*, *43*(1), 473–492. https://doi.org/10.1146/annurev-soc-060116-053442