The contribution of diffusion to the fertility transition in Belgium (1887–1934)

Abstract

The aim of this study is to investigate whether diffusion contributed to the geography and the speed of the fertility transition. To this end, we put together a new and unique dataset from historical sources in Belgium containing yearly information on fertility at the municipality level and a range of structural and cultural indicators over 47 years (1887–1934). We use this dataset in a diffusion model based on multilevel event-history analysis. We find that diffusion between neighbouring places influenced the geography of the fertility transition only in its early stages; and diffusion accelerated the speed at which municipalities initiated fertility decline at the onset of the transition. We argue that, in the early stages of the transition, the bulk of people's interactions was confined to their own communities and neighbouring places and, as such, new ideas, attitudes and information about fertility would spread among adjacent areas. Later on, since the turn of the twentieth century, the way people interacted in space was transformed by the growing urbanisation, the development of transportation infrastructure, labour migration, etc. In this new context, opportunities for social learning were less constrained by space.

Introduction

The nineteenth and twentieth centuries in Europe were marked by deep changes in fertility behaviour, in which couples began to deliberately limit their number of children. These changes led to an unparalleled and long-lasting decline in fertility levels, a process known as the fertility transition. Even though this transition affected every society in Europe, it did not happen everywhere at the same time and at the same rhythm. Rather, the transition from high to low fertility levels unfolded in specific patterns in space and time.

These patterns were first revealed by the European Fertility Project (EFP), led by Princeton University in the 1970s (Coale and Watkins 1986). Using spatial data on several European provinces and districts, this project showed that the fertility transition unfolded in Europe following particular spatiotemporal patterns, which mainly mirrored Europe's cultural and linguistic geography (Lesthaeghe and Neels 2002; Watkins 1986, 1990). Fertility decline appeared to have gradually spread across neighbouring places, especially if they shared a common language and despite their differences in socioeconomic development; by contrast, the spread seemed to be stalled by linguistic and cultural boundaries (Bocquet-Appel and Jakobi 1996; Knodel and van de Walle 1979; Watkins 1986).

These findings challenged the idea that fertility decline was uniquely caused by socioeconomic changes. Couples' decisions to limit their number of children did not seem to be only a response to new structural factors—such as industrialisation, urbanisation and decline in infant mortality (Kirk 1996; Reher 2004; Szreter 1993). Couples' fertility behaviour seemed to be also conditioned to cultural factors, namely secularisation and the moral acceptability of birth control (Cleland and Wilson 1987; Lesthaeghe 1983; Lesthaeghe and Surkyn 1988). Although the debate in the literature was long polarised between these two views (Carlsson 1966; Schellekens and van Poppel 2012), it is widely accepted that structural and cultural factors were preconditions for fertility decline (Coale 1973; Lesthaeghe and Neels 2002; Lesthaeghe and Vanderhoeft 2001). In fact, an extensive body of research has shown that structural and cultural changes worked as mutually reinforcing drivers of the transition (Breschi et al. 2014; Breschi, Fornasin, and Manfredini 2013; Dribe and Scalone 2014; Goldstein and Klüsener 2014; Lesthaeghe and Neels 2002; Murphy 2015; Van Bavel 2004).

However, the mechanisms behind the spatiotemporal patterns of fertility decline are still a matter of debate. On the one hand, it could be argued that structural and cultural changes did not affect all the groups of society at the same time and did not happen simultaneously in all places. This could explain the transition patterns in part. On the other hand, patterns of fertility decline were so contiguous and so consistent with the linguistic geography that it seemed that something else was at play. A diffusion process, via the exchange of ideas and information among people, could be shaping the spread of new fertility behaviour. In other words, the geography and speed of fertility decline could be influenced by the way individuals interacted and were connected in space.

The idea that diffusion played a role in the European fertility transition is not new. Many studies using individual-level data found evidence that individuals' change in fertility behaviour was influenced by their social networks and interpersonal contacts (Bras 2014; Matthys 2013; Van

Bavel 2004; Watkins and Danzi 1995). However, macro-level studies that look into the spatiotemporal patterns of the transition are less common. One reason is that these studies require rich datasets containing a range of indicators at a fine level of spatial and temporal detail. Such historical data are seldom available.

The Belgian fertility transition provides an outstanding setting for the study of diffusion. First, the circumstances of fertility decline have been largely documented in previous studies using different datasets and methods (Alter and Gutmann 2005; Alter, Oris, and Neven 2010; Eggerickx 2004; Lesthaeghe 1977; Lesthaeghe and Neels 2002; Van Bavel 2004). Second, the country has remarkable historical data sources that offer the opportunity to perform a detailed investigation of demographic changes in space and time. Third, despite its small size the Belgian territory is rich in diversity. It is crossed by a linguistic boundary from west to east, separating Dutch-speaking populations in Flanders and French-speaking populations in Wallonia. Within these linguistic regions, urban and industrial axes contrast with remote rural zones.

For this study we gathered data from different historical sources in Belgium to put together an original dataset with a fine level of spatial and temporal detail. This dataset contains yearly information on fertility and a range of structural and cultural indicators at the municipality and district levels covering most of the transition process (1887–1934). Drawing on map sequences and multilevel event-history analysis, we investigate the hypothesis that diffusion influenced the geography and the speed of the fertility transition.

Background

Since the European Fertility Project (Coale and Watkins 1986) we know that the fertility transition unfolded in Europe following particular spatiotemporal patterns. These patterns seemed to suggest that social interactions played a role in the transition process. In fact, the transition process in space and time coincided with the 'channels of social interaction' (Watkins 1990): it spread more quickly where people circulated, exchanged and spoke the same language. Once the transition began in one spot, neighbouring areas quickly followed, especially if they were interconnected by language, economic activities or transportation axes (Bongaarts and Watkins 1996; Lesthaeghe 1977; Watkins 1986).

The Belgian case became an emblematic example of these particular spatiotemporal patterns. In his work within the EFP, Lesthaeghe (1977) showed that fertility decline started much earlier among French-speaking districts in Wallonia and much later in Flanders. At first, in the mid-nineteenth century, a pioneering spot of low fertility appeared in a rural Walloon locality at the border with France. Around 1870 this low fertility spot began to expand towards the adjacent areas, and by the turn of the twentieth century fertility had started to drop in most Walloon districts. However, the transition process was halted at the linguistic border. By 1900, there were no signs of fertility decline in the Flemish-speaking communities close to the border, whereas a few kilometres from there, on the French-speaking side, the transition was well underway (Lesthaeghe 1977, 106–109). Once fertility decline started in Flanders—with a twenty-year delay—

it first spread along the Brussels-Antwerp axis, then quickly east- and westward to the rest of Flanders.

A logical explanation to these patterns observed in Belgium and in Europe was that ideas, information and attitudes related to fertility behaviour were being transmitted through interpersonal contact (Lesthaeghe and Neels 2002; Watkins 1990). This gave rise to the hypothesis that a diffusion process was at play in the fertility transition (Casterline 2001). The central idea behind the diffusion hypothesis is that couples did not make their fertility decisions independently of the decisions and behaviour of others. In fact, fertility decisions were made under a fair amount of uncertainty and, in order to gather relevant information, individuals had to turn to the ideas, attitudes and examples available to them (Montgomery and Casterline 1996).

These ideas, attitudes and examples could be related to any preconditions of fertility decline: they may involve contraceptive knowledge, economic factors or cultural/social norms (Lesthaeghe and Neels 2002; Palloni 2001). First, in order to limit their number of births, couples had to be aware of the actual ways to do it; knowledge on contraceptive techniques was therefore an important piece of information that was transmitted through social interactions (Casterline 2001; Montgomery and Casterline 1996). Second, people were likely to exchange ideas about the economic costs and benefits of bearing children. For most people, the actual consequences of structural shifts—such as urbanisation and industrialisation—were rather abstract. Often, individuals did not immediately know the costs linked to having children and the potential benefits children could bring under new economic circumstances; nor did they know the appropriate weights to ascribe to these costs and benefits (Bongaarts and Watkins 1996). It is in the form of stories and examples acquired through social interactions that they would make sense of new economic circumstances and their implications for fertility choices (Montgomery and Casterline 1996). Third, social interactions would have allowed couples to assess the 'social costs' of limiting their fertility, since this involved a risk of social sanction. In fact, fertility behaviour was subjected to social norms (Bernardi 2003; Lesthaeghe and Neels 2002; Montgomery and Casterline 1996; Watkins and Danzi 1995). Deliberate fertility control was proscribed by the Catholic church and was long morally condemned in European societies (Alter and Gutmann 2005). It was through the diffusion of new attitudes and values that fertility control would gradually become accepted.

The diffusion of such ideas, attitudes and examples is believed to operate through two main mechanisms: social learning and social influence. Social learning is a process that produces 'additional pieces of information essential to the decision-making process' (Bernardi 2003, 535), thus allowing individuals to gain knowledge and clarify the costs and benefits of adopting a new behaviour (Montgomery and Chung 1999). Social learning may arise from interpersonal interactions, such as conversations about fertility strategies with relatives and peers, as well as from impersonal interactions, by the simple exposure to the experience of others related to fertility (Bernardi 2003; Cleland 2001). Social influence, on the other hand, refers to the effect of the perception of others on individual behaviour (Montgomery and Casterline 1996). If parents, peers, hierarchical authorities or religious institutions impose sanctions or rewards to the adoption of new fertility behaviour, then individuals might consider these sanctions and rewards as part of their decision-making in order seek conformity and avoid conflict (Bernardi 2003; Bongaarts and Watkins 1996; Montgomery and Casterline 1996).

The way social learning and social influence operate is likely to depend on how individuals are interconnected. Diffusion of new ideas often occurs through heterogeneous relations, or 'weak ties' (Granovetter 1973). New ideas can flow more freely when individuals observe and interact with others from different places or social classes. By contrast, homogeneous networks create less opportunities for new ideas to appear (Van Bavel 2004) and are more prone to exert moral control that prevents change (Bongaarts and Watkins 1996). Hence, the more individuals would move and interact with people from different backgrounds, the easier new ideas about fertility would spread.

The importance of diffusion mechanisms such as social learning and social influence has been demonstrated in micro-level studies of the fertility transition. Van Bavel (2004) found evidence of social learning in his work on the fertility behaviour of working-class couples in Leuven (Belgium) during the onset of the fertility transition. Using individual data from population registers and civil records, he showed that working-class couples who interacted with groups who were early adopters of birth limitation (Francophone or upper-class) were more likely to adopt modern fertility behaviour. Matthys (2013) also found qualitative evidence of social learning among rural-born servants working in Ghent (Belgium) via gossip between co-workers and the observation of upper-class employers. In the Netherlands, Bras (2014) used information on marriage witnesses in order to approach couples' social networks based on the Historical Sample of the Netherlands (HSN) and marriage certificates. She found that couples whose networks were composed of lateral kin and age peers (hence with more opportunities for social learning) were more prone to adopt birth control; moreover, lower classes lagged behind in the transition not only due to socioeconomic factors, but also to more patriarchal networks (exerting social influence).

These diffusion mechanisms operating at the micro level could potentially influence the transition at the macro level, shaping the geography and the speed of fertility decline. Depending on the way people interacted in space, new fertility behaviour could spread more quickly via social learning or be stalled by social influence. Watkins (1990) argued that most of the social interaction in the past was confined to local communities. Conversational opportunities were limited because of the existence of local dialects, low spatial mobility and economic activities organised at the community level. The local nature of social interactions most probably inhibited the onset of fertility decline by limiting opportunities for social learning and encouraging social influence. As countries became politically, culturally and economically organised, not only did the costs and benefits of having children changed, but the 'channels of social interaction' began to expand. Socioeconomic development favoured labour migration, and the creation of transport and communication infrastructure fostered the flow of people and information within the countries. Moreover, the unification of the national language and the creation of national education systems helped break communication barriers. As new opportunities for social interaction arose, well beyond the local level, people could have more access to new examples and information about birth control, and they were less subjected to local social control.

The argumentation that diffusion mechanisms influenced the transition as a macro process is a plausible one. However, it is still unclear whether diffusion actually shaped the geography and speed of fertility decline. Studies using the EFP data described the spatiotemporal patterns of fertility decline and supported this argumentation, but they did not perform statistical tests to examine whether these patterns were due to diffusion or simply to cultural and structural changes

in space and time (Bocquet-Appel and Jakobi 1996; Lesthaeghe and Neels 2002; Watkins 1990). Surprisingly few spatial studies attempted to separate the diffusion process from the effect of other variables that might also influence the course of the transition.

In the context of the European fertility transition, only two studies so far—carried out quite recently—have attempted to isolate diffusion from other factors. Goldstein and Klüsener (2014) analysed the fertility transition in Prussia at the level of 400 *kreise* between 1890 and 1910, while Murphy (2015) did the same for France at the much coarser level of 83 *départements* between 1876 and 1896. Starting from panel datasets, these studies used spatial econometric models with a spatially lagged component to estimate (changes in) fertility levels. This component accounted for the fertility level (or change) in the neighbouring spatial units. Their results show that, even controlling for a large set of economic and cultural variables, the spatially lagged component remains highly significant. This suggests that the spatiotemporal patterns of fertility decline in Prussia and in France were not only due to structural and cultural changes: fertility decline in a given place was associated with fertility decline in the neighbouring places. The simple fact of being close to a low-fertility zone seemed to trigger the onset of fertility decline. These findings give support to the hypotheses that social interactions mattered and diffusion of ideas linked to fertility played a role in the transition.

Besides the spatial analyses of Prussia and France, recent works on Sweden using multilevel models have provided additional elements about diffusion (Dribe, Juárez, and Scalone 2017; Klüsener, Dribe, and Scalone 2019). Benefitting from full-count micro data from Swedish censuses at the onset of the fertility transition (1880, 1890, 1900), these works offer a more complex picture of how diffusion operated in space. Klüsener, Dribe, and Scalone (2019) found that fertility decline among upper-class women was less dependent on their spatial location, which corroborates the idea that elite's networks were not constrained by space and upper-class women had access to information on fertility across longer distances, beyond their place of residence. Furthermore, Dribe, Juárez, and Scalone (2017) analysed the variation in individual-level fertility within and between communities (parishes). They found that fertility levels can be mainly explained by individual characteristics, and only a small share can be attributed to community effects. Hence, this study suggests that if diffusion did take place in Sweden, it did not operate at the level of the local community but within social networks extending over longer distances.

A major challenge for the study of diffusion in historical fertility transitions is related to data availability. Ideally, in order to assess the diffusion process in spatiotemporal patterns we should have time series of several demographic, cultural and demographic variables covering an entire territory over a long period at a fine level of spatial and temporal detail. It is this fine level of detail that allows the identification of what is stirring fertility change in space and time. Unfortunately, such data series are seldom available and ready to use. Most of the data series in Europe are available only for a few points in time (at census years) and refer to large spatial units. The two existing studies at the macro level, on Prussia and France, managed to produce very rich insights on the role of diffusion, even though they rely on spaced-out observations for coarser spatial units (especially in the case of France). The multilevel studies using the remarkable Swedish data elucidated some complex aspects of diffusion at the micro level, but did not address the impact of diffusion at the macro level. Furthermore, the existing studies typically focused on the onset of the fertility transition spanning over twenty years at most and not on the whole transition

process. In this context, long data series with a high level spatial and temporal granularity could shed more light on the way diffusion might have operated during the European fertility transition.

In this study, we put together a new and unique dataset with a high level of spatial and temporal precision, which allows us to study spatiotemporal patterns of fertility change with an unprecedented level of detail. By using yearly data on fertility at the municipality level over half a century, this macro study has a higher granularity than the studies on France and Prussia and covers a longer period. We focus on the transition process as a macro process of demographic change: we aim to analyse *whether* diffusion played a role (rather than *what* was being diffused and *how*). Moreover, using a long observation period, we can assess this role at different stages of the fertility transition. Our central hypothesis is that *diffusion shaped the geography and the speed of fertility decline*—the corollary being that *the intensity of social interactions contributed to the spread of new fertility norms*.

Data and Methods[1]

Building a dataset from historical sources

Belgium has a long tradition in data collection and has produced consistent series of population data since the late nineteenth century. Most of these data, however, are not directly available in digital format. Hence, for the purpose of this study we gathered a unique body of data at a fine spatial level covering a long period of time (1880–1935). This body of data was gathered from two sources: the *Mouvement de la population et de l'état civil* and population censuses.

The *Mouvement de la population et de l'état civil* provides yearly demographic information at the municipality level from 1841 to 1976. The *Mouvement* was based on municipalities' population registers, which transcribed demographic facts from vital records—related to births, deaths, marriages and divorces—as well as information on in- and out-migration (Poulain 1981). Despite its great potential, the *Mouvement* remains largely underused so far due to the considerable task involved in digitising the data, since they have to be inputted manually (Bracke and Vanhaute 2005; Preneel 2010). For this study, we gathered demographic data for the approximately 2,600 municipalities (*commune/gemeente*) year by year from 1886 to 1935 (excluding the First World War years, for which the manuscripts are incomplete).

Whereas the *Mouvement* provides basic demographic data on a yearly basis, population censuses offer more detailed information on the state of the population every ten years. Population censuses have been organised regularly in Belgium since 1847 and aggregate results are available in printed volumes. Some results are reported at the municipality level, whereas others are only available at the level of the 41 districts (*arrondissement*). We gathered data from the six editions of the census between 1880 and 1930. We selected comparable socioeconomic data reported in different census years in order to obtain consistent time series. Whenever available, information

[1] See supporting material for more details on the data sources, spatial aggregation and measures.

at the municipality level was chosen over that at the district level. Similar to the *Mouvement*, most of these data had to be input manually.

Municipality data in the *Mouvement* and in the censuses correspond to 'old' municipalities from previous administrative divisions of Belgium. Many of these old municipalities had small population counts, leading to random fluctuation in the data series. Moreover, old municipalities changed constantly over time due to splittings and mergers. In order to avoid these problems, old municipalities were merged into larger spatial units. Urban centres with more than 10,000 inhabitants in 1900 were kept unchanged in order not to mix urban and rural areas. All the other towns and villages were merged according to the 'new' municipalities from the current administrative division of Belgium. In the end, we obtained 645 spatial units: 88 urban centres (that were kept unchanged) and 559 units resulting from the mergers of old towns and villages. For the sake of clarity, we refer to these spatial units simply as 'municipalities' throughout the text.

The final dataset offers a range of population and socioeconomic data from 1880 to 1935, including year-by-year data series at the level of 645 municipalities[2]. The dataset is unique in that it allows the monitoring of demographic change in Belgium over half a century with an unprecedented level of spatial and temporal detail. It is unfortunate that the period covered by the dataset leaves out the onset of fertility transition in some pioneering spots, which happened prior to 1880 (Lesthaeghe 1977); still, the period covered by the dataset includes most of the transition process. This long coverage represents an advance in respect to previous studies, which focus on the transition onset only and cover twenty-year periods (Dribe, Juárez, and Scalone 2017; Goldstein and Klüsener 2014; Murphy 2015).

Assessing marital fertility levels and transition timing

The fertility transition is a process in which fertility levels decline as an increasing number of couples choose to limit their number of births. In order to capture couples' fertility choices, studies traditionally used indicators of marital fertility based on legitimate births.

In this study we used Coale's marital fertility index I_g (Coale and Watkins 1986, app. B). This index compares the actual number of legitimate births at a given place to the theoretical number of births that would be observed if married women did not control their fertility. Its values can theoretically vary between 0 and 1, the upper value corresponding to the natural fertility level in the absence of any fertility control. Despite its many drawbacks[3], I_g remains a viable option for the study of historical fertility transitions when data availability is limited (see Guinnane, Okun, and Trussell 1994) and the index is still used in recent studies (Blanc 2019; Murphy 2015). In our case, our dataset allowed us to compute I_g for the 645 municipalities year by year between 1887 and 1913 and between 1920 and 1934[4]. As aforementioned, data is missing for the First World

[2] The data is openly available at [to be defined].

[3] See supporting material for a discussion on the limitations of the marital fertility index I_g.

[4] The index is calculated as follows:

$$I_g = \frac{b_l}{\sum_{a=15}^{49} m_a \times f_a}$$

where b_l is the number of legitimate births, m_a is the number of married women at age a and f_a the Hutterite's fertility rate at age a. The Hutterite's fertility rates by age (f_a) are known (Coale & Watkins, 1986, p. 154). The number of

War period. In order to complete the time series, we estimated I_g values for each municipality between 1914 and 1919 by linear interpolation.

Based on the I_g time series, we used two approaches to assess two distinct moments in the transition course: the onset of fertility transition and the attainment of an advanced stage of the transition (Fig. 1). The first approach—'10% drop'—looks at the year in which I_g permanently dropped by 10% of its pre-transitional level (Caldwell and Caldwell 2001; Coale and Watkins 1986). In practice, we first identified early transitions not covered by our dataset. We consider municipalities with $I_g < 0.7$ over the whole period to have already started their transition at an unknown year before 1887 (Lesthaeghe 1977, 92), i.e. they are left-censored. For all the other municipalities we took the I_g value in 1887 as a reference; we then defined the year of onset of fertility transition as the first year in which I_g permanently dropped below 90% of this reference value. If I_g had not dropped below this level by 1934, municipalities are right-censored. The second approach—'0.5 threshold'—looks at the year in which I_g permanently fell under the 0.5, which indicates that the transition was well underway (Lesthaeghe 1977). Again, municipalities whose maximum I_g level was lower (higher) than 0.5 over the whole period are left-censored (right-censored).

[Fig. 1 about here]

A limitation of our approaches and dataset is that they do not cover the entire transition in Belgium (Fig. 2). In fact, the year of onset (10% drop) is unknown for one third of municipalities; these are mainly situated in Wallonia, where fertility transition started earlier (70% left-censoring). In turn, there are fewer censored municipalities in the 0.5 threshold approach (8.1% left- and 9.8% right-censored); right-censoring is more common in Flanders (20%). Despite the censoring issues, the data series still allow us to observe most of the course of the transition. Most importantly, it allows us to assess transition timing with much more detail than previous studies based on ten- or five-yearly data on large spatial units.

[Fig. 2 about here]

Analytical strategy and models implementation

The first analytical step was to produce a sequence of I_g maps at the municipality level between 1887 and 1934. This was in order to observe and describe the spatiotemporal patterns of fertility transition in Belgium. If diffusion was at play, we can expect fertility decline to have followed a

legitimate births (b_i) by year and municipality was compiled from the *Mouvement* between 1886 and 1935 (except for the war years, 1914–1918). In order to avoid random fluctuations due to small numbers we smoothed the time series with a three-year aggregation of b_i centred on each year between 1887 and 1934. The number of married women by age (m_a) was not available at the municipal level. These data were thus compiled from the population censuses of 1890, 1890, 1900, 1910 and 1920 at the district level, distinguishing cities and towns in each district. By linear interpolation, annual standard age distributions were created for the period 1887–1934 and assigned to the municipalities according to their district and status (city/town). We assume that variations in age structures of married women among municipalities of a same district are minimal and have little effect on the index values (see supporting material).

contagion-like pattern, i.e. to have gradually spread across contiguous areas, within linguistic regions and along the main axes of communication.

However, a contagion pattern is not sufficient to support the diffusion hypothesis. It could be simply reflecting changes in other factors that are relevant to fertility decline—such as socioeconomic or cultural changes—if they also spread gradually in space. A contagion pattern is only evidence of diffusion if it is not shaped by other variables related to fertility decline (Goldstein and Klüsener 2014; Schmertmann, Assunção, and Potter 2010). Hence, in a second analytical step we estimated diffusion models based on multilevel event-history analysis in order to control for the spatiotemporal patterns of other relevant variables.

The third step consisted in a counterfactual analysis. We used the diffusion models to simulate the transition process in Belgium with and without diffusion. This allowed us to estimate the contribution of diffusion to the speed of the transition.

All the analyses, maps and graphs were made in R (R Core Team 2020)[5].

Models specification

The motivation behind diffusion models is to isolate diffusion from all the other variables that are likely to influence the dependent variable (Casterline 2001; Goldstein and Klüsener 2014). From a macro perspective, the occurrence of a given event in spatial unit i at time (year) t is a function of the occurrence of the same event in geographically close units j at time $t-1$, as well as of all the other relevant variables at time $t-1$. We departed from this general framework to estimate multilevel discrete-time event-history models with random intercepts, based on the two approaches of transition timing (10% drop and 0.5 threshold).

Our event of interest is the fertility transition in a given municipality at a given moment (Y_{it}). The model can be represented as follows:

$$\ln\left(\frac{P(Y_{it})}{1-P(Y_{it})}\right) = \alpha_t + \beta_1 T_{it} + \beta_2 \boldsymbol{X}_{it-\bullet} + \delta \boldsymbol{Y}_{jt-1} + (\varepsilon_{it} + u_i)$$

The dependent variable is the logit-transformation of the probability of municipality i to experience the transition at time t. The 'experience of transition' refers to our definitions of transition timing: municipality i is said to experience fertility transition at the year in which I_g permanently dropped by 10% compared to the pre-transitional level ('10% drop model') or below 0.5 ('0.5 threshold model')

The right-hand side of the equation is composed of four main components other than the intercept α_t. First, T_{it} denotes period-dependence since 1888. Period-dependence was included in the model by five-year periods (except the first and last periods: 3 and 4 years respectively). This is to accommodate the non-linear trend over time. The choice of five-year periods rather than single years also avoids random fluctuations in transition hazards towards the end of the observation period due to the small number of transitions. Second, $\boldsymbol{X}_{it-*}$ denotes a set of structural, cultural and social network characteristics of municipality i, lagged by • years, which are likely to

[5] The codes are available along with the data at [to be defined].

influence its chances of experiencing fertility decline at time *t*. Third, $\mathbf{Y}_{jt-1}$ is a set of period-dummies capturing diffusion effects in each period: for a given municipality *i* at time *t* in period *T*, a dummy accounts for the first occurrence of fertility transition in a neighbouring municipality *j* at time $t-1$. The coefficient δ can be thus considered as a diffusion coefficient, 'net' of other relevant factors that might influence the timing of the transition. Finally, the models' residuals are decomposed in two terms: the first at the level of the municipality at a given year (ε_{it}) and the second at the level of municipalities (u_i). The decomposition of residuals into these two terms creates a hierarchical structure in the model by allowing the intercept to vary between municipalities. This multilevel structure partially accounts for unobserved heterogeneity between municipalities that could influence their odds of experiencing the fertility transition.

The models were fitted on a municipality-year datasets in which municipalities appear as many times as the number of years 'at risk' of experiencing fertility transition. The time origin is 1888. The last row in which a municipality appears in the dataset corresponds either to its transition year or to right-censoring (in 1934). Municipalities which experienced the fertility transition before 1888 were excluded from the analysis (left-censored). In total there were 6,780 municipality-years in the 10% drop model and 17,082 municipality-years in the 0.5 threshold model.

Diffusion period-dummies

If diffusion was at play, we can expect that a given municipality would be more likely to experience the transition if a near-by municipality experienced the transition in the recent past. However, we can also expect that such diffusion effects would not have acted in the same manner in all stages of the fertility transition: its impact could have changed as structural and cultural conditions evolved and as social networks became more developed across space.

We modelled diffusion in two steps. First we created a binary term accounting for the presence of at least one neighbouring municipality which experienced the transition within a time-window of five years. For a given municipality *i* at time *t*, this term takes value 1 if the first neighbouring municipality *j* experienced the fertility transition at $t-1$, and keeps value 1 for maximum five year before going back to 0. As such, this term captures the short-term effect of the transition in a neighbouring municipality. A neighbouring municipality is one that shares at least one border point (first-order queen contiguity). Second, we made this term interact with period by including it in the model as a set of dummies, one by period. For period *T*, the dummy can only vary between 0 and 1 within the years in T, and has value 0 in all other years. The 0.5 threshold model includes dummies for the ten periods, while the 10% drop model only includes nine dummies because there were no transitions in the period 1931–1934.

The choice of a time-window of five years is somewhat arbitrary. However, varying the time-window between tree and ten years has little impact on the results. The motivation of using a short time-window is to concentrate on the 'shock' of the transition in the neighbouring area. Moreover, this is a conservative way of modelling diffusion since the chance that non-observed factors intervene at precisely the same time as a neighbouring transition is low.

Socioeconomic, cultural and network covariates

The vector $\boldsymbol{X}_{it-*}$ includes eight indicators compiled from censuses and the *Mouvement* at different moments between 1880 and 1930. Most variables were computed for each municipality at ten-year intervals between 1880 and 1930. By linear interpolation we obtained yearly time series (see Hedström 1994). This way, indicators' values vary year after year in the event-history models.

Variables were included in the models using different time lags. In the absence of diffusion, socioeconomic and cultural shifts are expected to have an immediate impact on fertility behaviour. Therefore, most of the variables were lagged by one year only. However, some of the covariates might be related to diffusion process *within* the municipalities. For example, a rise in the proportion French-speaking in a municipality would have a delayed impact on fertility behaviour because diffusion mechanisms within the municipality would first have to take place through social interaction. The same is true for the proportion non-natives and population density. For this reason, these three variables were included in the models with a five-year lag[6].

Four socioeconomic variables reflect different aspects of the structural changes that might have altered couples' fertility choices:

- The *proportion of the male adult population employed as blue-collar in the industrial sector* (1-year lag) is an indicator of the municipalities' industrialisation level. Industrialisation is thought to have changed the costs and benefits of childbearing: large families became economically disadvantageous in an industrial context (Bongaarts and Watkins 1996; Kirk 1996) and were increasingly perceived as an obstacle to social mobility (Eggerickx 2004). Therefore, this industrialisation variable is likely to have a positive impact on the municipalities' odds of experiencing fertility transition.

- Likewise, the *female labour force employed in industrial and trade sectors* (1-year lag), i.e. non-traditional sectors, might have increased the costs of childbearing and contributed to fertility decline (Folbre 1983; Galloway, Hammel, and Lee 1994). Besides, working women would have had more opportunities to be in contact with the world outside the household and thus become more exposed to information about the costs and benefits of childrearing and the moral acceptability of birth limitation (Mason 2001; McDonald 2000). Hence, the progression in female labour should also have a positive effect on the odds of fertility transition.

- The municipalities' *literacy rate* (1-year lag) is employed as a proxy for the educational level. Education would have given individuals access to information and provided them with autonomy to make conscious reproductive choices (Mason 2001; McDonald 2000). Furthermore, as children's education became compulsory, it had a direct impact on the costs of childrearing, contributing further to birth limitation (Kirk 1996). As a result, as literacy rates rises in a municipality, its likelihood of experiencing fertility transition should also rise.

- Improvements in the chances of child survival—measured here by the *infant mortality rate* (1-year lag)—would imply that couples had to bear less children in order to attain their desired family size (Easterlin and Crimmins 1985; Reher 1999; van de Walle 1986). In other words, a

[6] Tests with the event-history models have shown, nonetheless, that a variation from one- to five-year lags have very little impact on the results.

fall in infant mortality rates should be associated with higher odds of experiencing fertility transition.

Two cultural variables refer to the municipalities' secularisation level and linguistic distribution:

- Secularisation and the shift away from a traditional and religious frame of reference would have made birth control morally acceptable and changed couples' attitudes in respect to fertility (Blanc 2019; Lesthaeghe 1977; Lesthaeghe and Neels 2002). A proxy for secularisation is obtained by the *Marriages in Lent index* (MLI) (1-year lag). As marriages during the Lent were proscribed by the Catholic Church, the intensity of marriages in March can be used as an indicator of the observation of religious norms and the moral and social control imposed by the community (Lesthaeghe 1991). The indicator relates the number of marriages in March to the monthly average over a year. Higher values indicate that the marriage ban during Lent is not observed in the municipality—hence higher levels of secularisation.

- It is known that secular ideas and values were disseminated earlier within French-speaking populations (Blanc 2019; Lesthaeghe 1977; Lesthaeghe and Lopez-Gay 2013) and that the presence of Francophone minorities in Flanders contributed to the spread of modern fertility behaviour (Van Bavel 2004). In this sense, the *proportion of French-speaking population* (5-year lag) is an indicator of the municipalities' exposure to the progressive ideas and attitudes that circulated in the 'francophone world'. Because of the linguistic composition of Belgium, the distribution of this variable across municipalities is highly asymmetric. In order to separate the effect of this variable in both sides of the linguistic border, municipalities were grouped into five categories. Municipalities with a Francophone majority (80–100%) are assembled in one group, which covers most of Wallonia. The second group (30–80%) is composed of 35 bilingual municipalities situated at the linguistic border, at the Luxembourg and Dutch borders and in Brussels. The other three groups (less than 30%) convey the presence of French-speaking minorities in Flanders and the French-speaking Flemish elite.

Finally, the variables set $\boldsymbol{X}_{it-*}$ includes two indicators of municipalities' *social networks*.

- The *proportion of non-natives* (5-year lag) is a measure of heterogeneity in a municipality's population. Heterogeneous networks would allow new values and attitudes to flow more freely (Granovetter 1973). Thus, residents born in another municipality and socialised in a different context might have brought with them innovative views in respect to fertility behaviour. In addition, they were likely to be less embedded in the local social networks and thus less subjected to moral control regarding traditional fertility behaviour (Eggerickx, Bahri, and Sanderson 2008; Van Bavel 2004).

- The *population density* (5-year lag) is an indicator of the intensity of social interactions. In municipalities where population density was high, social interaction should have been more intense and new ideas about fertility should have flown more easily, which could have a positive impact on fertility decline.

The eight covariates (Tab. 1) globally reflect the structural and cultural changes in Belgium since the end of the nineteenth century (see Lesthaeghe 1977, chap. 2). Overall, the period was

marked by a rise in industrial work and literacy levels and a fall in mortality rates. Also, secularisation progressed, as suggested by the rise in the Marriages in Lent index. On the other hand, the female labour force remained stable over the period. This is probably due to the fact that female participation in traditional proto-industrial sectors was already high at the turn of the twentieth century, especially in Flanders (Lesthaeghe 1977).

[Tab. 1 about here]

Each numerical variable was tested for potential nonlinear effects. Two covariates were shown to have a nonlinear relationship with the dependent variable: population density and industrialisation (proportion male blue-collar). Therefore, square terms of these covariates were included in the final models.

Models computation

Tab. 2 brings an overview of the covariates included in the models. All the covariates are time-varying. For each model—10% drop and 0.5 threshold—we first tested the gross effect of the diffusion period-dummies (base models). Next, we computed full models including all the covariates (full models). The models were fitted by binary logistic regression for general linear mixed-effects models using the lme4 package in R (Bates et al. 2015).

[Tab. 2 about here]

Results

Descriptive analysis: the spatiotemporal patterns of fertility decline

Fig. 3 and Fig. 4 present a sequence of maps depicting the spatial distribution of marital fertility levels before and after the First World War[7]. All the maps were produced using the same categories of I_g. Fertility control is likely to be absent in areas displaying I_g levels above 0.7 and municipalities in this category can thus be considered as pre-transitional (Lesthaeghe 1977).

[Fig. 3 about here]

[Fig. 4 about here]

At the beginning of the observation period (1887), a considerable number of municipalities had not yet started their fertility transition ($I_g > 0.7$). These pre-transitional municipalities were mostly situated in the Dutch-speaking part of Belgium, as well as in the rural south-east (Ardennes). The lowest levels of marital fertility were found within a layer of municipalities in the south-west (provinces of Hainaut and Namur), stretching along the French border. This early-

[7] See animated time lapse with year-by-year maps in the online additional material.

transition zone had an I_g level already below 0.5 in 1887 and was composed of both industrial and rural areas.

From the 1890s until the early twentieth century, fertility decline gradually spread from this early-transition area to the rest of Wallonia, along the industrial axis (Charleroi-Namur-Liege) rapidly attaining low levels ($I_g < 0.35$). During this period marital fertility also started to decline in Brussels and adjoining municipalities and in the Flemish major urban areas (Antwerp and Ghent). Interestingly, Flemish municipalities situated at French border also experienced some fertility decline during this period, much earlier that the rest of Flanders.

The linguistic border played an important barrier effect on the spread of fertility decline. There is a clear distinction of fertility levels between the two main linguistic regions throughout the entire period. With the exception of the major cities, nearly all the Flemish municipalities experienced a very late decline compared to Wallonia. Most Dutch-speaking municipalities situated at the linguistic border displayed pre-transitional fertility levels until the first decade of the twentieth century, whereas their French-speaking neighbours were already in an advanced stage of the fertility transition ($I_g < 0.5$).

It was not until the 1910s that fertility decline began to penetrate into Flanders. This occurred along two main axes: Brussels-Antwerp and Brussels-Ghent-Bruges. From there, it later spread to the rest of the Dutch-speaking municipalities, especially after First World War. Municipalities in the north-east (Limburg) were latecomers of the fertility transition: by 1934, the signs of fertility decline were hardly starting to appear.

The general spatiotemporal patterns described here are consistent with those found by Lesthaeghe (1977) using ten-yearly observations at the district level. Nevertheless, the yearly observations at the municipal level offer a more detailed picture of the Belgian fertility transition. In particular, three patterns stand out from the maps sequence.

First, the propagation of fertility decline showed by the maps follows a strikingly contiguous path. The fall in I_g values spread gradually among neighbouring areas, year after year, first within Wallonia and later into the north of the linguistic border.

Second, this gradual spread first took place along the industrial and urban axes in Wallonia and in Flanders, following the main transportation networks (Laffut 1998). By contrast, fertility decline was delayed in areas that were less connected to the industrial/urban axes (namely the Ardennes in Wallonia and the Limburg province in Flanders).

Finally, national and linguistic borders seem to have played an important role in the spatiotemporal patterns of fertility decline. On the one hand, the proximity to the French border was associated with an earlier transition. All the Walloon municipalities situated at the French border—rural and urban—had I_g values below 0.7 in 1887, indicating their early fertility transition. Dutch-speaking municipalities at the French border also experienced an earlier decline compared to the rest of Flanders. On the other hand, the linguistic border in Belgium delayed the spread of modern fertility behaviour from Wallonia to Flanders and it appears as a clear divide of marital fertility levels throughout the first part of the twentieth century.

Diffusion models: the impact of diffusion on the fertility transition

We used discrete-time multilevel event history analysis as a way to model the observed spatiotemporal patterns while controlling for other relevant variables. Tab. 3 displays the results of the diffusion models.

[Tab. 3 about here]

The evolution of municipalities' transition odds over the years is consistent with the spatiotemporal patterns described above. For the 10% drop model, municipalities' odds of starting fertility decline become significantly higher after 1900, compared to 1888–1890 (reference years). In fact, the turn of the twentieth century corresponds to the moment in which the linguistic border halted the spread of modern fertility into Flanders (see maps sequence in Fig. 3). Once the decline started in Flanders between 1900 and 1910, the transition process accelerated, as indicated by the high and significant transition odds ratios in this period. In the 0.5 model transition odds are markedly higher from the early twentieth century on. The process accelerated in the 1920's, when an increasing number of Flemish municipalities finally caught up with the transition process.

The gross effects of the diffusion period-dummies are positive and highly significant for the periods 1888–1890 and 1891–1895 in both models, and for the period 1901–1905 for the 0.5 threshold model. Once we introduce socioeconomic, cultural and social networks variables (full models), the effects of these diffusion dummies decrease, but remain positive and significant for the two first periods ($p < .05$). This indicates that socioeconomic and cultural changes in space and time do account for some of the spatiotemporal patterns of fertility decline; however, there seems to be an independent spatial element at play in the early stages of the transition. In 1888–1890, municipalities were nine times more likely to initiate the fertility decline (10% drop) if a neighbouring municipality had initiated the decline in the past five years; and four times more likely to reach an advanced stage of the transition (0.5 threshold) if a neighbouring municipality reached that stage in the past five years . In 1891–1895 the odds were somewhat lower, around 2.5 in both models. These results suggest that diffusion influenced the geography of the transition before the end of the nineteenth century: fertility decline in one place had an effect on the neighbouring places in the following few years, net of structural and cultural factors.

Among the socioeconomic variables, industrialisation has the strongest effect on transition odds. When the share of male blue-collars in the industrial sector increase by 10%, municipalities are twice as likely to start their transition (10% drop) and nine times as likely to reach an advanced stage of the transition (0.5 threshold) ($p < .001$). The impact of this variable is higher in the 0.5 threshold model because this model covers a larger and more heterogeneous portion of the Belgian territory. In both models, the effect of industrialisation is not linear (the square terms are significant). The total effect of industrialisation is depicted in Fig. 5a. Industrial work has an increasingly positive impact on the odds of experiencing the fertility transition, but it reaches a maximum effect around 50%. Once a municipality is already highly industrialised the effect of the variable becomes less important. In other words, the onset of industrialisation seems to have a greater impact on the course of the transition, compared to later stages of industrial development.

[Fig. 5 about here]

The results for infant mortality rate and female labour differ between the two models. In the 0.5 threshold model, female labour is not significant, whereas infant mortality has the expected effect: higher infant mortality is associated with lower odds of transition (*OR* = 0.87; p < .001). By contrast, in the 10% drop model, female labour has the expected positive impact (*OR* = 1.17; $p < .05$), whereas infant mortality has a low but positive impact (*OR* = 1.05; $p < .05$). These results in the 10% drop model could be due to the fact that this model covers mainly the onset of the transition in Flanders and the south of Wallonia. In the specific occupational structure in the western part of Flanders, the high participation of women in the labour market and the low wages and could have triggered the onset of fertility decline and, at the same time, maintained high levels of infant mortality (Galloway, Lee, and Hammel 1998; Masuy-Stroobant 1983).

Literacy is only significant in the 0.5 threshold model. As expected, literacy has a positive association with fertility decline: when the literacy rate increases by 10%, municipalities are 70% more likely to reach an advanced stage of the transition ($p < .001$). Again, the non-significant effect of literacy in the 10% drop model may be due to the fact that this model covers mainly Flanders and the south of Wallonia: the variation in education level across these areas is not large enough to capture the effects of literacy on the transition onset. In all cases, it is important to acknowledge that the literacy rate is a rudimentary indication of education level and had overall little spatial variation at the turn of the twentieth century.

Among the cultural variables, the knowledge of French has a significant impact in the transition timing. Municipalities in which more than 10% of the inhabitants spoke French were more likely to experience the fertility transition than those in which less than 5% did (reference category), net of other factors. Municipalities with a Francophone majority (80–100%), mostly situated in Wallonia, had the highest odds of fertility transition (*OR* = 4.8 and 12.9 respectively in the two models with $p < .001$). But even in Flanders the knowledge of French increased the odds: municipalities where 10 to 30% of the inhabitants speak French were around twice likely to experience the fertility transition compared to the reference category. Furthermore, the secularisation proxy (Marriage in Lent index) has the expected effect as well: an increase in secularisation is associated with increased odds of fertility transition (*OR* = 1.05 and 1.08 with $p < .05$).

Regarding the network variables, population density stands out with a positive and significant effect on the timing of fertility decline in both models. An increase of 1,000 inhabitants per square kilometre doubles municipalities' likelihood of experiencing the transition. The square term included in the regressions is significant for the 0.5 threshold model, which indicates a nonlinear effect of this variable. When we consider the total effect of population density on the dependent variable (Fig. 5b), odds ratios increase until around 8,000 inhabitants per square kilometre and slightly decreases after that level. This suggests the existence of a saturation point, after which the impact of an increase in a municipality's density stalls. Population density was used as a proxy of the intensity of social interactions: people had more opportunities for social learning in densely populated places. However, it is logical to think that these opportunities did not increase linearly, and the number of interactions a person can have might reach a limit. By contrast the second network variable—proportion of non-natives—was non-significant in both models. This

variable was included as a proxy of 'weak ties' in the social networks, i.e. the interaction with and exposure to people from different backgrounds. This was shown to foster the adoption of modern fertility behaviour at the micro level (Bras 2014; Van Bavel 2004). However, at the macro level, the variable of non-natives may not be an appropriate proxy for 'weak ties' as it is closely linked to population density (albeit with a smaller range of variation). In fact, the proportion of non-natives becomes significant when population density is dropped (not shown).

The residuals deviance tests presented on Tab. 4 are a way of assessing the contribution of each covariate to the full models. The tests compare the goodness of fit of the full models to a model dropping one variable at a time. The values indicate how much the deviance of the residuals increases as we drop each variable from the full model. Period set apart, the diffusion period-dummies has the greatest contribution in the goodness of fit of the 10% drop, followed by the linguistic composition (% French-speaking). In the 0.5 threshold model, the contribution of the diffusion period-dummies is relatively less important: the most powerful factors seem to be industrialisation, the linguistic composition and population density.

[Tab. 4 about here]

It is important to acknowledge that the diffusion dummies in 1888–1890 and 1891–1895 may be capturing the effect of unobserved variables that are highly clustered in space and time. In fact, the socioeconomic and cultural indicators computed from the available data are very generic measures. More precise indicators would perhaps show variations in culture and living conditions that are captured by our diffusion dummies. Still, there are reasons to believe that the diffusion dummies in 1888–1890 and 1891–1895 reflect indeed diffusion effects, and not unobserved variables.

First, more precise indicators of culture or living conditions would in practice be more detailed versions of the variables already included in the analyses. It is unlikely that they would be so much more clustered in space and time as to explain away all the observed effect the diffusion dummies in 1888–1890 and 1891–1895.

Second, we designed the diffusion period-dummies to capture the effect of a transition in a neighbouring municipality within five years. This was a conservative strategy of modelling diffusion because it makes it less probable that a dummy would capture the effect of unobserved changes other than fertility transition in a neighbouring municipality. For this to happen, such changes would have to intervene at the same short window of time as the transition in a neighbouring place. It is also reassuring that the dummies for the periods after 1891–1895 are neither significant in the base models nor in the full models (except for 1901–1905 in the 0.5 threshold model). If significant dummies had lost their effect after the inclusion of covariates, this would be an indication that the dummies were in fact capturing structural and cultural factors.

Third, the inclusion of random intercepts partially controls for unobserved heterogeneity between municipalities that are not captured by the data. Of note, a simple model without random intercepts yield nearly identical results (not shown).

Finally, we performed sensitivity tests by rerunning the models dropping one significant variable at a time, then looking at the variation in the coefficient of the diffusion period-dummies in 1888–1890 and 1891–1895 (Goldstein and Klüsener 2014). If a diffusion dummy is capturing

the effect of any of these variables, we expect its coefficient to increase when the variable is dropped. In the 10% model, dropping population density leads to a 7.5% increase in the diffusion dummy in 1888–1890. When any other variable is dropped, the coefficient decreases or changes very little. In the 0.5 threshold model, dropping literacy has the most significant increase in the diffusion dummy in 1891–1895 (+18%). Dropping all other variables—including industrialisation—has little impact. These tests indicate that it is unlikely that unobserved variables would explain away the effect of the diffusion dummies in 1888–1890 and 1891–1895. For this to happen, unobserved variables would have to have a larger effect on the transition odds than the variables that are already included in the model.

[Fig. 7 about here]

Counterfactual analysis: how diffusion influenced the speed of transition

The results of the diffusion models suggest that diffusion contributed to the spatial patterns of the fertility transition in its early stages: the transition was more likely to start at a place when it also started in neighbouring places in the previous years. However, these results do not indicate how diffusion might have contributed to the speed of the transition process, i.e. to the rate at which municipalities transitioned over the years.

In order to measure the impact of diffusion on the speed of the transition, we used the diffusion models to simulate the fertility transition under three different scenarios. For each model, we computed the predicted probabilities of transition for municipalities by period (i) using the real values of the diffusion period-dummies, (ii) setting all period-dummies to 0, and (iii) setting each period-dummies to 1 for its corresponding period (0 otherwise). We then applied these predicted probabilities to the 'surviving' number of municipalities at the beginning of each period. The results are shown in figure 6. The dashed curves represent the real pace of the transition as fitted by the model 'transition with diffusion' (i). The dark-shaded curves represent the scenario of 'transition without diffusion' (ii), in which diffusion has no effect (neighbouring municipalities never experience the fertility transition). The light-shaded curves represent the scenario of 'transition with maximum diffusion' (iii), in which diffusion is at its maximum (there is always a neighbouring municipality which has recently experienced the transition). By comparing the curves, it is possible to estimate the impact of diffusion on the speed of fertility transition. The graphs indicate the points in which 75%, 50% and 25% of municipalities had not yet transitioned, thus cutting the transition process into quarters.

[Fig. 6 about here]

In the 10% drop model, diffusion seems to have accelerated the transition process in its early stages. A transition without diffusion would have reached the first quarter (75%) with a half-decade delay. In other words, diffusion represented a gain of approximately five years in the first quarter of the transition. However, this 'sprint' produced by diffusion dissipated after 1900 as the 'transition without diffusion' caught up: by the third quarter of the transition (25%), there is only a negligible difference between the curves with and without diffusion. By contrast, in the scenario

with maximum diffusion, the transition process would have been about eight years faster: before 1900, more than half of municipalities would have already transitioned.

The impact of diffusion on the transition speed is much more limited in the 0.5 threshold model. If there were no diffusion, the transition course would have been delayed only by a year or so at the early stages. In a scenario with maximum diffusion, the process would have been accelerated in the very beginning, before 1900, but this advantage would have quickly disappeared. After 1915, when more than half of municipalities were still above the I_g threshold of 0.5, diffusion seems to play no role at all in the transition (as the three curves converge).

This counterfactual analysis indicates that diffusion sped up the very onset of fertility decline in municipalities (10% drop in I_g), especially in the early stages of the transition. Without diffusion, it would have taken additional five years to reach the first quarter of the transition. On the other hand, once fertility decline started, diffusion did not significantly speed up the decline itself: the rate at which municipalities' I_g dropped below the 0.5 threshold would not have been different with or without diffusion.

Discussion

The idea that diffusion played a role in fertility transitions is not new. Whereas many studies have looked into diffusion mechanisms at the micro level, few studies have investigated how diffusion could have shaped the transition process at the macro level. Research on diffusion at the macro level is often hampered by data availability, since it requires a great amount of demographic, social and economic data covering a long period of time at a fine spatial level. For this study we put together a new and unique dataset based on historical statistical sources in Belgium and offering a high level of spatial and temporal granularity. To our knowledge, this is the first study on the European fertility transition to use yearly fertility indicators at the municipality level. The dataset allowed us to assess the spatiotemporal patterns of the fertility transition with an unprecedented level of detail and to construct diffusion models based on multilevel event-history analysis.

Our analyses give some support to the hypothesis that diffusion played a role in the fertility transition. The descriptive analysis reveals that fertility decline in Belgium followed a contagion-like pattern in space and time, gradually unfolding over the years among neighbouring municipalities. However, the diffusion models indicate that this contagion-like pattern of fertility decline is partially explained by cultural and structural factors, in line with previous research (Goldstein and Klüsener 2014; Lesthaeghe and Neels 2002; Murphy 2015). Yet, a substantial part of this pattern remains unexplained by cultural and structural variables in the early stages of the fertility transition. For the periods 1888–1890 and 1891–1895, municipalities were respectively nine and two times more likely to initiate their fertility decline if a neighbouring municipality had initiated its fertility decline in past five years. In the same periods, municipalities were between four and three times more likely to reach an advanced stage in the transition if a neighbouring municipality had reached it in the recent past. In other words, there seems to be a spatial logic during the first stages of the transition that is adding to cultural and structural changes: once fertility decline started in a given area, it was also likely to start in adjacent areas shortly after, net

of other factors. Moreover, our simulations suggest that diffusion accelerated the kick-off of fertility decline during these early stages of the transition. Without diffusion, the onset of the transition would have been delayed by roughly five years. However, this 'sprint' provoked by diffusion was later absorbed as diffusion between neighbouring places lost its momentum.

In sum, our analyses yield two main findings. First, diffusion between neighbouring places influenced the *geography* of the fertility transition in its early stages, before the turn of the twentieth century. Second, diffusion accelerated the *speed* at which municipalities initiated fertility decline at the onset of the transition, although this acceleration did not have a substantial impact on the end result of the transition.

The models could be missing important variables. Misspecification is in fact an inherent risk of diffusion models at the macro level, since 'diffusion' is typically captured by the residual space-time pattern that is not explained by other covariates (Goldstein and Klüsener 2014). In our case, we cannot exclude the possibility that unobserved factors may be shaping the contagion pattern of fertility decline. In fact, the available data only allowed us to compute basic indicators of structural and cultural change; more detailed variables could have explained a greater portion of fertility change in space and time. However, sensitivity tests indicate that it is unlikely that unobserved factors would explain away the 'diffusion effect' obtained in our models. If misspecification is not behind our results, then it is likely that social interactions indeed played a role in the way the fertility transition unfolded in space and time.

Our main finding—that diffusion between neighbouring places was a driver of fertility decline at the onset of the transition, but not at later stages—is consistent with Watkins' theory of diffusion (1990). Her hypothesis is that the 'channels of social interaction' in the past were limited to the local level, whereas they later expanded as the modernisation process unfolded (Watkins 1990). Accordingly, it is possible that, until the end of the nineteenth century in Belgium, the bulk of people's interactions was confined to their own communities and the neighbouring places. As such, mechanisms of social learning would operate mainly at short distances: new ideas, attitudes and information around fertility strategies would spread among adjacent areas. Later on, from the turn of the twentieth century, the way people interacted in space could have been transformed by the growing urbanisation, the development of transportation infrastructure, labour migration, etc. In this new context, opportunities for social learning were less constrained by space. If diffusion still had an effect on fertility under these new circumstances, this effect would not be so clustered in space.

Apart from the diffusion process between neighbouring places, other findings in our studies support the idea that social interactions mattered in the transition. As suggested by Watkins (1990) and in line with Goldstein and Klüsener (2014), we found that fertility decline spread more rapidly in and around urban centres and along the main transportation axes. That is, fertility decline spread through places where there were more opportunities for social interaction and exchanges. Besides, population density was shown to have been an important trigger of fertility decline, but after a certain level (around 8,000 inhabitants per square kilometre) its effect stalled. This is an interesting result since it suggests that densely populated places, where people interacted more, were more likely to experience fertility decline, but at the same time it is reasonable to think that the opportunities for social interaction reach a saturation point in highly dense areas.

In line with Lesthaeghe (1977), our results show that the fertility transition had an important linguistic component. The pioneering spots in fertility decline in Belgium were rural localities close to the French border. Fertility decline seems to have gradually spread among French-speaking municipalities, until this contagion process was stalled by linguistic border: fertility decline was much delayed in Flanders. Besides, as suggested by our models, the presence of people in Flemish municipalities that had some knowledge of French seemed to be a trigger of fertility decline. Inasmuch as language is an important component of social interaction, we argue that ideas about fertility were flowing by interpersonal communication.

All these findings lead us to believe that a diffusion process through social interaction mattered in the fertility transition: the way people were interconnected likely played a role in the way fertility decline spread in space and time.

The actual mechanisms through which diffusion might have operated at the individual level cannot be deciphered in a macro study such as this one. Still, we can speculate that diffusion acted as an intermediary process between macro-level changes and their effects on couples' fertility behaviour. It is indisputable that what ultimately caused fertility to decline were the profound structural and cultural changes taking place since the nineteenth century. But it is reasonable to assume that couples were not immediately aware of how these changes could affect their lives and how they should adapt their fertility strategies accordingly. It was likely by social interaction that couples could make sense of new economic costs and benefits of having children as well as the social risks of limiting childbearing. Hence, diffusion can be regarded not as a direct determinant of fertility decline, but as a vector of change, carrying the effect of economic and cultural factors and translating them into new fertility norms. In sum, our study gives support to the idea that, in the context of demographic change, the causality links between macro-level determinants and individual behaviour are not necessarily straightforward: macro determinants may be mediated by channels of diffusion before translating into actual change in individual behaviour. To the extent that these channels of diffusion depend on the way people interact in space, they will contribute to the geography and to the speed of social change over time.

An important next step in the field is to delve into the intricate relations between diffusion, space and demographic change—not only at the onset of the fertility transition but also at later stages. Recent evidence from Sweden suggests that the interplay between diffusion and space was already complex at the onset of the fertility transition (Dribe, Juárez, and Scalone 2017), namely among upper-class women whose social networks extended over longer distances (Klüsener, Dribe, and Scalone 2019). In the same vein, our findings for Belgium suggest that the contribution of diffusion to the transition was unchained from space as modernisation unfolded and social interactions expanded beyond the local level. Future research should investigate how the configuration of social networks changed as the fertility transition progressed, and whether diffusion mechanisms such as social learning continued to influence fertility decline across longer distances. This would also contribute to a better understanding of the later stages of the transition, which have gained little attention in the literature so far.

Finally, beyond the historical fertility transition, the Second Demographic Transition is a rich setting to further investigate the links between diffusion, space and demographic change. In fact, these links might have become even more intricate since the second half of the twentieth

century, as social network have grown more complex with the fast development of information and communications technologies.

References

Alter, G., and M. Gutmann. 2005. "Belgian Historical Demography as Viewed from North America: Protoindustrialization, Fertility Decline, and the Use of Population Registers." *Journal of Belgian History* XXXV (4): 523-546.

Alter, G., M. Oris, and M. Neven. 2010. Le déclin de la fécondité dans les campagnes de Belgique orientale. Illustration d'une réponse multiphasique. In *Histoire de la population de la Belgique et de ses territoires*: Presses Universitaires de Louvain.

Bates, D, M Mächler, B Bolker, and S Walker. 2015. "Fitting Linear Mixed-Effects Models Using lme4." *Journal of Statistical Software* 67, no. 1: 1-48. https://doi.org/10.18637/jss.v067.i01.

Bernardi, L. 2003. "Channels of Social Influence on Reproduction." *Population Research and Policy Review* 22 (5-6): 427-555.

Blanc, Guillaume. 2019. "Modernization Before Industrialization: Cultural Roots of the Demographic Transition in France." HAL-02318180v2.

Bocquet-Appel, J. P., and L. Jakobi. 1996. Barriers to the Spatial Diffusion for the Demographic Transition in Western Europe. In *Spatial Analysis of Biodemographic Data*: John Libbey Eurotext and Institut National d'Etudes Démographiques.

Bongaarts, J., and S. C. Watkins. 1996. "Social Interactions and Contemporary Fertility Transitions." *Population and Development Review* 22 (4): 639-682.

Bracke, N., and E. Vanhaute. 2005. *Opsporing en Ontsluiting van Historische Statistieken in België (1800-1960).* (Final report of a study for the Belgian Science Population Office).

Bras, H. 2014. "Structural and diffusion effects in the Dutch fertility transition, 1870-1940." *Demographic Research* S14 (5): 151-186.

Breschi, M., M. Esposito, S. Mazzoni, and L. Pozzi. 2014. "Fertility transition and social stratification in the town of Alghero, Sardinia (1866-1935)." *Demographic Research* S14 (28): 823-852.

Breschi, M., A. Fornasin, and M. Manfredini. 2013. "Patterns of reproductive behavior in transitional Italy: The rediscovery of the Italian fertility survey of 1961." *Demographic Research* S14 (44): 1227-1260.

Caldwell, J. C., and P. Caldwell. 2001. "Regional Paths to Fertility Transition." *Journal of Population Research* 18 (2): 91-117.

Carlsson, G. 1966. "The Decline of Fertility: Innovation or Adjustment Process." *Population Studies* 20 (2): 149-174.

Casterline, J. B. 2001. Diffusion Processes and Fertility Transition: Introduction. In *Diffusion Process and Fertility Transition*: National Academy Press.

Cleland, J. 2001. Potatoes and Pills: An Overview of Innovation-Diffusion Contributions to Explanations of Fertility Decline. In *Diffusion Process and Fertility Transition*: National Academy Press.

Cleland, J., and C. Wilson. 1987. "Demand Theories of the Fertility Transition: an Iconoclastic View." *Population Studies* 41 (1): 5-30.

Coale, A. J. 1973. "The demographic transition reconsidered." Proceeding of the International Population Conference 1973.

Coale, A. J., and S. C. Watkins. 1986. *The Decline of Fertility in Europe*. Princeton University Press.

Dribe, M., S. P. Juárez, and F. Scalone. 2017. "Is it who you are or where you live? Community effects on net fertility at the onset of fertility decline: A multilevel analysis using Swedish micro-census data." *Population, Space and Place* 23 (2): e1987.

Dribe, M., and F. Scalone. 2014. "Social class and net fertility before, during, and after the demographic transition: A micro-level analysis of Sweden 1880-1970." *Demographic Research* S14 (15): 429-464.

Easterlin, R. A., and E. C. Crimmins. 1985. *The Fertility Revolution. A Supply-Demand Analysis*. The University of Chicago Press.

Eggerickx, T. 2004. La dynamique démographique et la transition de la fécondité dans le bassin industriel de la région de Charleroi, de 1831 à 1910. In *Histoire quantitative et développement de la Belgique aux XIXe et XXe siècles*: Académie Royale de Belgique.
Eggerickx, T., A. Bahri, and J. P. Sanderson. 2008. "Contrôle social et moral du mariage et de la fécondité en Belgique au 19ème siècle. Le cas du bassin industriel de Charleroi." international conference Démographie et Cultures, Québec.
Folbre, N. 1983. "Of Patriarchy Born: The Political Economy of Fertility Decisions." *Feminist Studies* 9 (2): 261-284.
Galloway, P. R., E. A. Hammel, and R. D. Lee. 1994. "Fertility Decline in Prussia, 1875-1910: A Pooled Cross-Section Time Series Analysis." *Population Studies* 48 (1): 135-158.
Galloway, P. R., R. D. Lee, and E. A. Hammel. 1998. Infant Mortality and the Fertility Transition: Macro Evidence from Europe and New Findings from Prussia. In *From Death to Birth. Mortality Decline and Reproductive Change*: National Academy Press.
Goldstein, J. R., and S. Klüsener. 2014. "Spatial Analysis of the Causes of Fertility Decline in Prussia." *Population and Development Review* 40 (3): 497-525.
Granovetter, M. S. 1973. "The Strength of Weak Ties." *American Journal of Sociology* 78 (6): 1360-380.
Guinnane, T. W., B. S. Okun, and J. Trussell. 1994. "What Do We Know About the Timing of Fertility Transitions in Europe?" *Demography* 31 (1): 1-20.
Hedström, P. 1994. "Contagious Collectivities: On the Spatial Diffusion of Swedish Trade Unions, 1890-1940." *American Journal of Sociology* 99 (5): 1157-1179.
Kirk, D. 1996. "Demographic Transition Theory." *Population Studies* 50 (3): 361-387.
Klüsener, Sebastian, Martin Dribe, and Francesco Scalone. 2019. "Spatial and Social Distance at the Onset of the Fertility Transition: Sweden, 1880–1900." *Demography* 56 (1): 169-199. https://doi.org/10.1007/s13524-018-0737-9. https://doi.org/10.1007/s13524-018-0737-9.
Knodel, J., and E. van de Walle. 1979. "Lessons from the Past: Policy Implications of Historical Fertility Studies." *Population and Development Review* 5 (2): 217-245.
Laffut, M. 1998. Les chemins de fer belges 1830-1913. Genèse du réseau et présentation critique des données statistiques. In *Histoire quantitative et développement de la Belgique aux XIXe et XXe siècles*: Académie Royale de Belgique.
Lesthaeghe, R. 1977. *The Decline of Belgian Fertility, 1800-1970*. Princeton University Press.
---. 1983. "A Century of Demographic and Cultural Change in Western Europe: An Exploration of Underlying Dimensions." *Population and Development Review* 9 (3): 411-435.
---. 1991. Moral control, secularization and reproduction in Belgium (1600-1900). In *Historiens et Populations. Liber Amicorum Etienne Hélin*: SBD-Académia.
Lesthaeghe, R., and A. Lopez-Gay. 2013. "Spatial continuities and discontinuities in two successive demographic transitions: Spain and Belgium, 1880-2010." *Demographic Research* 28 (4): 77-136.
Lesthaeghe, R., and K. Neels. 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* 18: 325-360.
Lesthaeghe, R., and J. Surkyn. 1988. "Cultural Dynamics and Economic Theories of Fertility Change." *Population and Development Review* 14 (1): 1-45.
Lesthaeghe, R., and C. Vanderhoeft. 2001. Ready, Willing, and Able: A Conceptualisation of Transitions to New Behavioral Forms. In *Diffusion Process and Fertility Transition*: National Academy Press.
Mason, K. O. 2001. "Gender and Family Systems in the Fertility Transition." *Population and Development Review* 27: 160-176.
Masuy-Stroobant, G. 1983. "Les déterminants individuels et régionaux de la mortalité infantile : la Belgique d'hier et d'aujourd'hui." Université Catholique de Louvain.
Matthys, C. 2013. "Domestic servants and diffusion of fertility control in Flanders, 1830--1930." *The History of the Family* 18 (4): 456-480.
McDonald, P. 2000. "Gender Equity in Theories of Fertility Transition." *Population and Development Review* 26 (3): 427-439.
Montgomery, M. R., and J. B. Casterline. 1996. "Social Learning, Social Influence, and New Models of Fertility." *Population and Development Review* 22: 151-175.
Montgomery, M. R., and W. Chung. 1999. Social Networks and the Diffusion of Fertility Control in the Republic of Korea. In *Dynamics of Values in Fertility Change*: Oxford University Press.

Murphy, T. E. 2015. "Old Habits Die Hard (Sometimes). Can département heterogeneity tell us something about the French fertility decline?" *Journal of Economic Growth*: 1-46.
Palloni, A. 2001. Diffusion in Sociological Analysis. In *Diffusion Process and Fertility Transition*: National Academy Press.
Poulain, M. 1981. "Evolution des statistiques démographiques belges disponibles au niveau communal depuis la fin du XVIIIe siècle." *Revue Belge de Géographie* (105/5): 205-217.
Preneel, M. 2010. Over levendgeboren onwettige meerlingen in Wortel, Luikse emigratie naar Argentinië en epidemische meningitis in Zedelgem. "Le mouvement de la Population et de l'État Civil" (1841-1976): een nauwelijks ontgonnen bron voor historisch-demografische statistiek in België. In *Histoire de la population de la Belgique et de ses territoires*: Presses Universitaires de Louvain.
R Core Team. 2020. R: A language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing.
Reher, D. S. 1999. "Back to the basics: mortality and fertility interactions during the demographic transition." *Continuity and Change* 14 (1): 9-31.
---. 2004. "The demographic transition revisited as a global process." *Population, Space and Place* 10 (1): 19-41.
Schellekens, J., and F. van Poppel. 2012. "Marital Fertility Decline in the Netherlands: Child Mortality, Real Wages, and Unemployment, 1860-1939." *Demography* 49: 965-988.
Schmertmann, C. P., R. M. Assunção, and J. E. Potter. 2010. "Knox meets Cox: Adapting epidemiological space-time statistics to demographic studies." *Demography* 47 (3): 629-650.
Szreter, S. 1993. "The Idea of Demographic Transition and the Study of Fertility Change: A Critical Intellectual History." *Population and Development Review* 19 (4): 659-701.
Van Bavel, J. 2004. "Diffusion Effects in the European Fertility Transition: Historical Evidence from Within a Belgian Town (1846-1910)." *European Journal of Population* 20: 63-85.
van de Walle, F. 1986. Infant Mortality and the European Demographic Transition. In *The Decline of Fertility in Europe*, edited by A. J. Coale and S. C. Watkins: Princeton University Press.
Watkins, S. C. 1986. Conclusions. In *The Decline of Fertility in Europe*: Princeton University Press.
---. 1990. "From Local to National Communities: The Transformation of Demographic Regimes in Western Europe, 1870-1960." *Population and Development Review* 16 (2): 241-272.
Watkins, S. C., and A. D. Danzi. 1995. "Women's Gossip and Social Change: Childbirth and Fertility Control among Italian and Jewish Women in the United States, 1920-1940." *Gender and Society* 9 (4): 469-490.

Tab.1: Descriptive statistics: socioeconomic indicators in 1890 and 1920 calculated on the 645 municipalities

Covariate	Year	Mean	St. dev.	Min	Max
Proportion male blue-collar (%)	1890	26.9	15.6	4.6	64.8
	1920	36.1	13.1	8.4	65.9
Proportion female labour (%)	1890	15.8	7.2	5.4	44.5
	1920	15.6	7.2	5.0	36.5
Literacy rate (%)	1890	62.7	10.1	26.5	87.1
	1920	82.9	4.6	62.3	92.5
Infant mortality rate (‰)	1890	144.3	37.7	97.7	304.2
	1920	105.1	26.9	42.8	249.4
Proportion French-speaking (%)	1890	50.2	44.0	1.3	100.0
	1920	49.2	42.3	0.5	98.8
Marriages in Lent index (%)	1888	49.0	27.5	0.0	158.5
	1921	62.9	28.8	0.0	141.2
Proportion non-natives (%)	1890	31.2	11.8	2.8	78.5
	1920	36.9	13.0	7.1	95.6
Population density (inhab./km2)	1890	539	1,710	20	26,203
	1920	721	2,254	25	28,085

Sources: *Mouvement de la population et de l'état civil* and population censuses (own calculations)

Tab. 2: The independent variables included in the event-history models

	Variable	Computation	Measure	Type	Time lag (years)	Expected effect
Period	Period	3- to 5-year periods	Time	Categorical	-	+
Diffusion	Diffusion period-dummies	Presence or absence of at least one neighbouring municipality which has experienced the fertility transition within 5 years at a given period	Diffusion	Binary	1	+
Socioeconomic	Industrialisation	Proportion of men working as blue-collar among the districts' male population aged 15 to 65	Proxy of the districts' industrialisation level	Numerical	1	+
	Female labour	Proportion of women working in industry and trade among districts' female population aged 15 to 65	Participation of women in non-traditional sectors	Numerical	1	+
	Literacy rate	Share of literate inhabitants among the municipalities' total population	Education	Numerical	1	+
	Infant mortality rate	Number of deaths before age one among the districts' total number of living births	Chances of child survival	Numerical	1	–
Cultural	Secularisation	Number of marriages in March divided by the mean monthly number of marriages over the year	Respect of the norms imposed by the Church and by social and moral control	Numerical	1	+
	% French-speaking	Share of people with knowledge of French (as first or second language) among the municipalities' total population	Exposure to the Francophone progressive values	Categorical	5	+
Networks	% non-natives	Proportion of residents born in another municipality in the total population	Networks heterogeneity	Numerical	5	+
	Population density	Number of inhabitants per km²	Intensity of social interactions	Numerical	5	+

Tab. 3: Multilevel event-history analysis of municipalities' likelihood of experiencing fertility decline: logit regression results (general linear mixed-effects models)—odds ratios

	10% drop model		0.5 threshold model	
.	gross	net	gross	net
Period				
Period (ref = 1888–1890)				
1891–1895	1.59	1.93*	2.10	2.86*
1896–1900	1.62	1.73	2.70*	4.08**
1901–1905	6.40***	7.42***	7.06***	15.51***
1906–1910	10.90***	15.80***	5.42***	23.83***
1911–1915	8.20***	14.97***	6.03***	30.52***
1916–1920	5.13***	11.48***	6.90***	26.83***
1921–1925	6.31***	13.36***	14.33***	43.84***
1926–1930	6.45***	13.47***	23.49***	67.27***
1931–1934	15.83***	36.49***	44.15***	137.43***
Diffusion				
Diffusion period-dummies (ref = 0)				
1888–1890	11.03***	8.86***	13.55***	4.11*
1891–1895	3.11***	2.36***	8.75***	2.60**
1896–1900	1.73	1.60	2.01	0.43
1901–1905	0.98	0.89	3.49***	1.34
1906–1910	0.82	0.82	1.30	0.58
1911–1915	0.59	0.84	0.73	0.49
1916–1920	0.00	0.00	1.09	0.89
1921–1925	1.31	2.14	1.05	0.94
1926–1930	0.00	0.00	1.33	1.71
1931–1934	-	-	0.60	0.79

*** p<.001; ** p<.01; * p<.05
Two-tailed tests performed by bootstrap with 1,000 replications
Sources: *Mouvement de la population et de l'état civil* and Population censuses (own calculations)

Tab. 3: Continued

.	10% drop model		0.5 threshold model	
	gross	net	gross	net
Socioeconomic variables				
Literacy rate (scale: 10%)		0.95		1.68***
Infant mortality rate (scale: 10‰)		1.05*		0.87***
Female labour (scale: 10% female workers)		1.17*		1.08
Industrialisation (scale: 10% male blue-collar)		2.18***		8.56***
Industrialisation-squared		0.91**		0.82***
Cultural variables				
% French-speaking (ref = 0–5%)				
5–10%		1.23		1.27
10–30%		1.80***		2.23***
30–80%		2.35**		3.77***
80–100%		4.77***		12.94***
Secularisation (scale: 10% Marriages in Lent Index)		1.05*		1.08**
Social networks variables				
Population density (scale: 1,000 inh./km²)		1.70**		3.69***
Population density-squared		0.97		0.92***
% non-native (scale: 10%)		0.95		1.12
Models' parameters				
N. municipality-years	6,780	6,780	17,082	17,082
N. municipalities	436	436	593	593
Variance random effects	~0.0	~0.0	~0.0	0.7
AIC	3014.8	2868.3	4353.8	3750.8
BIC	3151.3	3093.4	4516.4	4014.2
Log likelihood	-1487.4	-1401.1	-2155.9	-1841.4
Deviance (-2LL)	2974.8	2802.3	4311.8	3682.8
df residuals	6760	6747	17061	17048

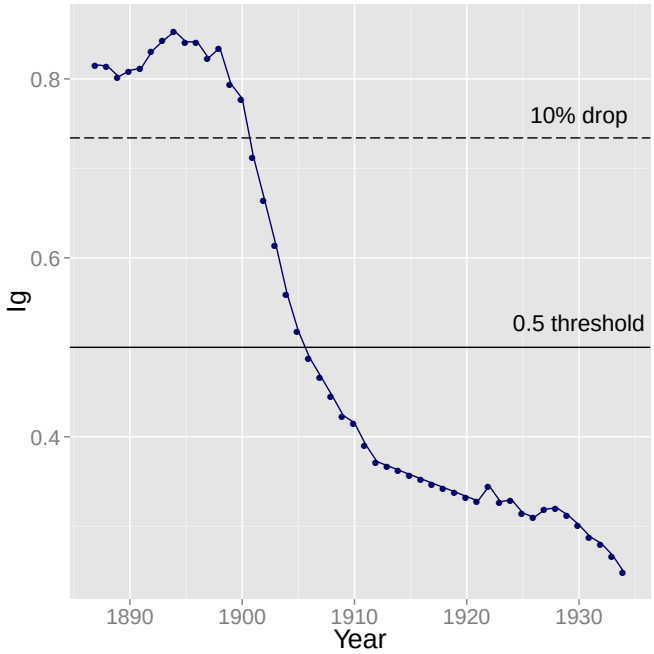
*** p<.001; ** p<.01; * p<.05
Two-tailed tests performed by bootstrap with 1,000 replications
Sources: *Mouvement de la population et de l'état civil* and population censuses (own calculations)

Tab. 4: The contribution of each covariate to the full models: residuals deviance tests

	Δ df	Δ –2LL	
		10% drop model	0.5 threshold model
Period	9	159.1***	153.2***
Diffusion period-dummies	9/10	59.9***	25.4**
Literacy rate	1	0.4	20.8***
Infant mortality rate	1	5.7*	28.2 ***
Female labour	1	6.2*	1.0
Industrialisation (regular + squared)	2	18.6***	141.7***
% French-speaking	4	54.8***	107.1***
Secularisation	1	4.7*	8.7**
Population density (regular + squared)	2	15.4***	87.6***
% non-native	1	0.7	3.1

*** p<.001; ** p<.01; * p<.05, Chi-squared tests
Sources: *Mouvement de la population et de l'état civil* and population censuses (own calculations)

Fig. 1: Example of an I_g yearly series and the assessment of transition timing in a mid-sized municipality (Ronse, 1887-1934)



Marital fertility level fluctuated around 0.8 before 1900, when it finally started to fall. The year of onset of fertility transition (10% drop approach) is 1901: this is when I_g permanently dropped below 90% of the reference level (in 1887). The year in which the municipality attained an advanced stage of the transition (0.5 threshold approach) in 1906, when I_g permanently fell below 0.5. Sources: *Mouvement de la population et de l'état civil* and population censuses (own calculations)

Fig. 2: Observed transitions, right- and left-censoring

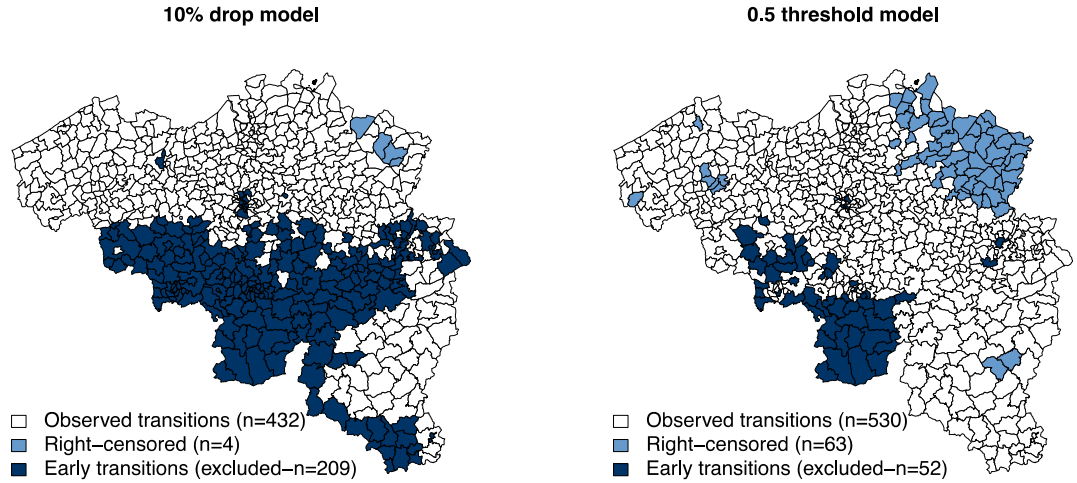
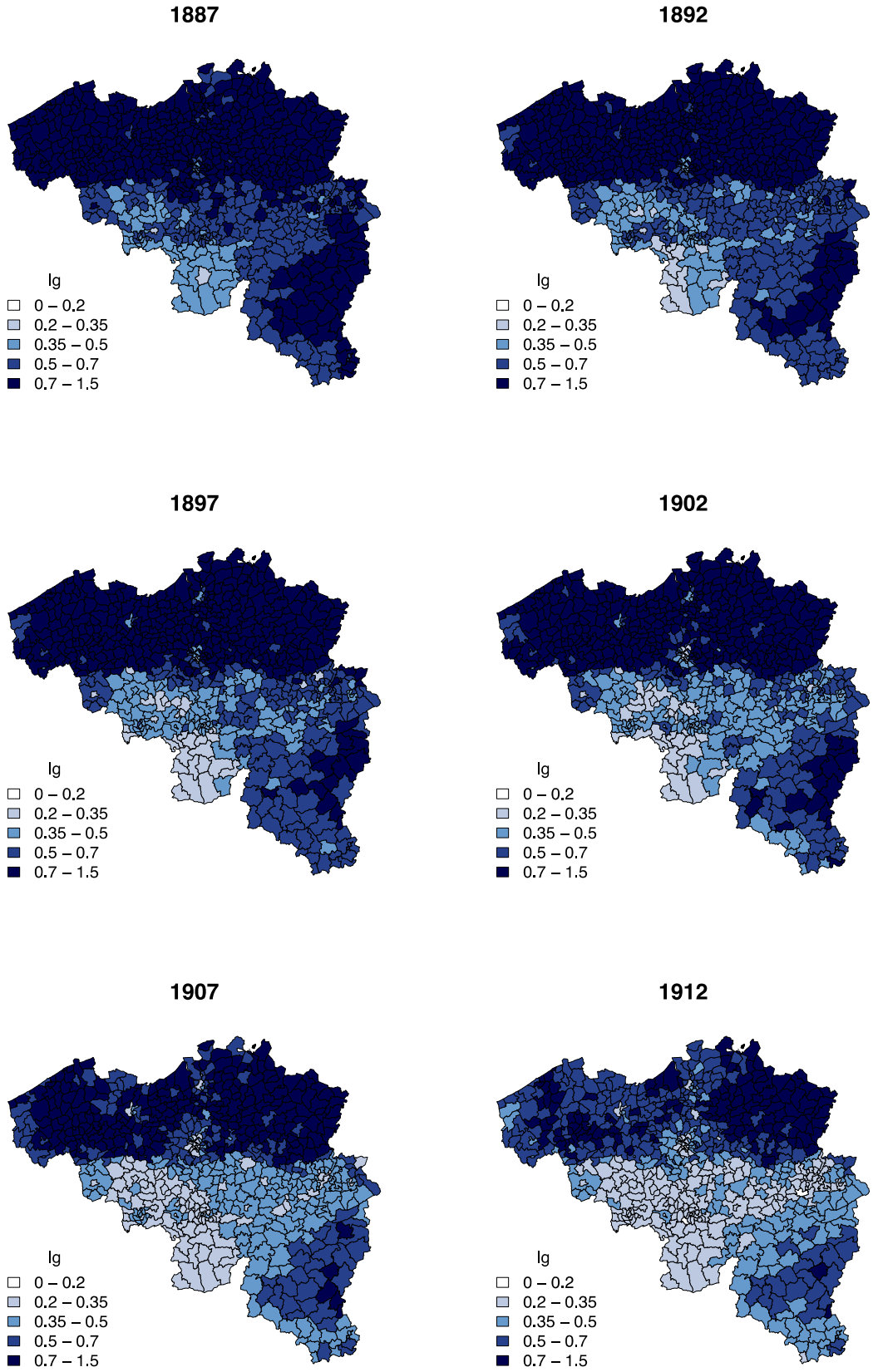
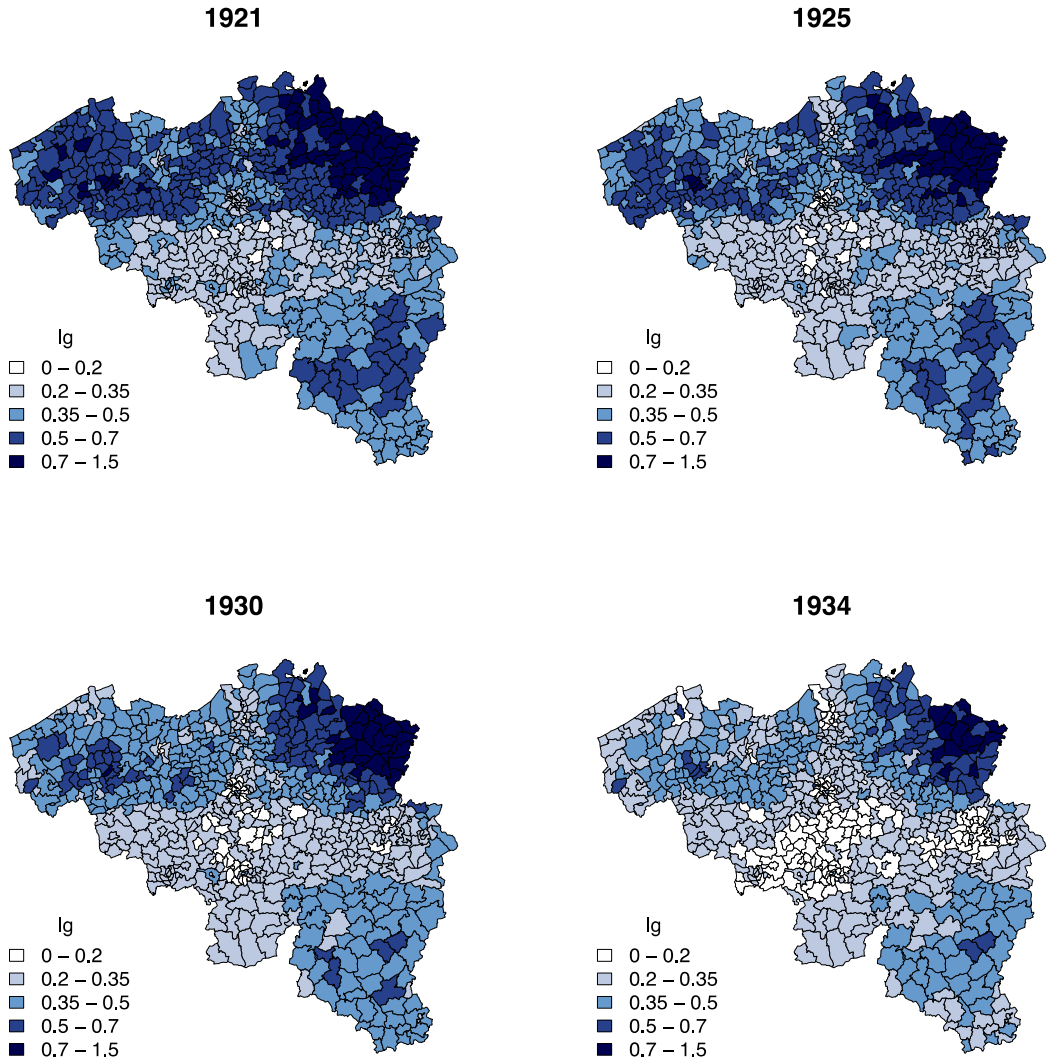


Fig. 3: Municipal distribution of the marital fertility index (I_g) 1887–1912



Sources: *Mouvement de la population et de l'état civil* and population censuses (own calculations)

Fig. 4: Municipal distribution of the marital fertility index (I_g) 1921–1934



Sources: *Mouvement de la population et de l'état civil* and population censuses (own calculations)

Fig. 5: Total effects of nonlinear variables



Sources: *Mouvement de la population et de l'état civil* and population censuses (own calculations)

Fig. 6: Number of municipalities which had not yet experienced the transition by period: models' prediction and simulation with no diffusion and maximum diffusion (full models)

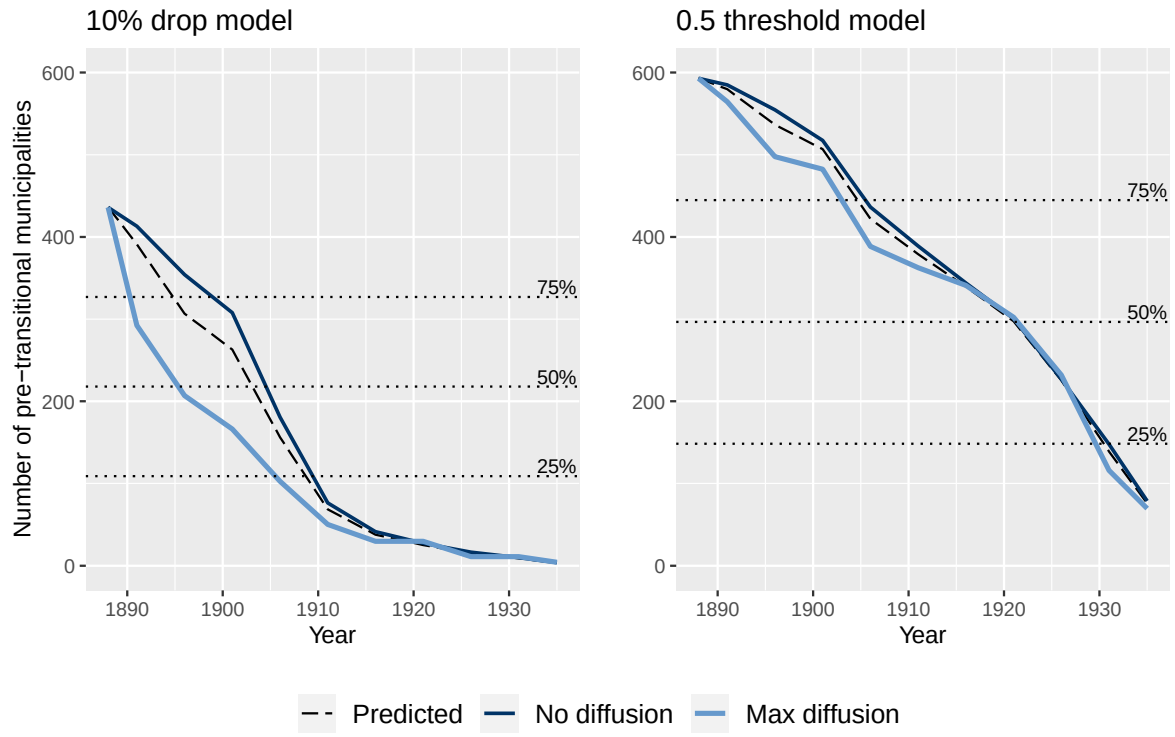


Fig. 7: Sensitivity tests: change in the coefficient of diffusion period-dummies as each significant covariate is dropped out of the model

