The influence of European Integration on convergence in life expectancy between Dutch border- and non-border regions: A longitudinal analysis between 1988-2021

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Abstract

Despite improvements over time, health inequalities persist between and within European countries. However, it remains unclear to what extent the European Integration's developments (i.e. the principles of free movement, funds, cross-border cooperation and the right to equal treatment) affected the relatively disadvantaged border regions. These regions have likely benefitted directly from increased (economic) activity and cooperation after opening the borders (core-periphery model), allowing them to catch up in health (convergence-divergence framework).
Hence, the current study aims to assess the role of European Integration on convergence in life expectancy trajectories between Dutch border- and non-border regions, including the role of contextual factors and spatial patterns. Convergence in life expectancy trajectories is assessed with line graphs (RQ1), spatial patterns are investigated with maps (RQ1a) and the role of contextual factors is studied with a fixed effects panel regression (RQ1b). The results provide no compelling evidence of convergence in life expectancy trajectories since the European Integration (1992), likely because social- and health policies remained a national responsibility and the improvement in border regions' attractiveness could be limited. The regression analysis indicates that a catch up of GDP per capita, employment and relative population growth (for women) in border regions are associated with convergence. Directions for future research point to continuing this line of research in a less homogenous (cross-border) context, study all non-border regions and increase the number of contextual factors. Policy recommendations emphasise improved data availability and regional initiatives to boost economic growth and the attractiveness of the most disadvantaged border regions.

Keywords: *European Integration, life expectancy, border region, convergence, the Netherlands, living conditions, divergence-convergence framework, core-periphery model, fixed effects panel regression.*

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BE = Belgium
COROP = Coördinatiecommissie Regionaal OnderzoeksProgramma
DE = Germany
$e0$ = Life expectancy at birth
$e65$ = Remaining life expectancy at age 65
EI = European Integration
EU = European Union
NUTS = Nomenclature of Territorial units for Statistics
TLA = Total Land Area

1. BACKGROUND

1.1. Problem statement

The Treaty signed in 1992 by the European leaders - the Maastricht Treaty - has celebrated its 30th anniversary in 2022. This Treaty is considered the foundation of the European Union (EU) and contributed to the strengthening of the integration among Member States; the European Integration (EI) (Sternberg, 2013; Barth & Bijsmans, 2018). It brought about the principles of free movement of capital, goods, services and people, the availability of funds as well as the right to equal treatment in every Member State (Favell & Recchi, 2009). As a result, the European Integration has contributed to nationally improved living conditions, which can be observed in labour market effects (Illing, 2023), total factor productivity (TFP) (Padilla, 2020), income per capita (Campos, Coricelli, & Moretti, 2019) and Gross Domestic Product (GDP) per capita (Orlowski, 2020; Zhao, Shi, & Li, 2022). Economic growth in turn is associated with increasing life expectancies (Jetter, Laudage, & Stadelmann, 2019; Kennelly, O'Shea, & Garvey, 2003; Miladinov, 2020; Shkolnikov, Andreev, Tursun-zade, & Leon, 2019), which serves as a primary measure of population health and the quality of life (OECD, 2021).

The main aim of the EU is to achieve a strong and united Europe, which is why one of the goals of the European Integration process is to reduce economic and health differences in its Member States (European Commission, 2020). The EU's efforts contributed to reducing health inequalities among the Member States (Scholz, 2020). For instance, health outcomes have improved for lower educated men (Mackenbach et al., 2018), infant mortality has declined, particularly in Eastern Europe (Onambele et al., 2019), the working life expectancy at age 50 has increased in most European regions (Loichinger & Weber, 2016) and Europe's citizens generally live longer and healthier than ever before (Scholz, 2020).

Despite significant health gains over time, health differences still persist across Member States today (Marmot, Allen, Bell, Bloomer, & Goldblatt, 2012; McGillivray & Markova, 2010). Inequalities in health are – at least partly – socially driven, making them unfair and unjust (Eikemo, Bambra, Huijts, & Fitzgerald, 2017). There is a significant gap in life expectancy between the Western European and the lagging Central- and Eastern European countries (Leon, 2011; Gerry, Raskina, & Tsyplakova, 2018), the difference in life expectancy encompasses almost nine years between countries with the lowest and highest life expectancies (Scholz, 2020) and infant mortality rates are almost four times higher in Romania than in Finland (Scholz, 2020). Hence, the goal of "grand convergence" in global health is estimated to be achieved in the year 2060, rather than in the targeted year 2035 (Goli, Moradhvaj, Chakravorty, & Rammohan, 2019).

Differences in health are not bound to the cross-national level; they also pose a challenge within countries (Huijts, Stornes, Eikemo, & Bambra, 2017; Thomson et al., 2017; Richardson, Pearce, Mitchell, Shortt, & Tunstall, 2013). Regional inequalities in health have been studied to a lesser extent, but they are assessed within Czechia (Bělohradský & Glocker, 2019), Spain (Zueras & Rentería, 2020), Hungary (Uzzoli & Szilágyi, 2009), Austria (Gächter & Theurl, 2011), Germany (Tetzlaff, Epping, Sperlich, & Tetzlaff, 2020) and the Netherlands (Groenewegen, Westert, & Boshuizen, 2003; Janssen, van den Hende, de Beer, & van Wissen, 2016). However, health disparities between the most- and least advantaged groups of society remain widely understudied (Braveman & Tarimo, 2002). Consequently, no literature has been found to study regional differences in health between border- and non-border regions and how these might have changed since the European Integration.

Traditionally, border regions are more disadvantaged than their non-bordering counterparts (European Commission, 2017). Due to their distance to the country's core, border regions receive less support from central governments (Schebesch & Tomé, 2014). Moreover, they have a less well developed infrastructure, relatively many low-skilled workers and relatively high unemployment rates (Nijkamp, 1993). Healthy people tend to migrate to places with more opportunities (Gächter & Theurl, 2011), making it likely that the (healthy) border regions' citizens migrate to the more economically prosperous non-border regions. Border regions are thus faced with population decline (Young, 2010) and an ageing population (Anđelković-Stoilković, Devedžić, & Vojković, 2018). Prior to the Maastricht Treaty, the difference in life expectancy between border- and non-border regions could have thus been relatively large, as lower socioeconomic groups tend to have higher risks of developing health problems than higher socioeconomic groups (Mladovsky et al., 2009). Considering that border regions are adjacent to country borders, they have likely benefitted directly from the aforementioned European Integration's developments, making them important locations for economic and social interactions,

cooperation and innovation (De Sousa, 2012). These developments could have enhanced border regions' health, as the social determinants of health entail factors such as socioeconomic status, educational level, employment, living conditions, social support networks and access to healthcare (Artiga & Hinton, 2018). Therefore, it is worthwhile to investigate whether and to what extent the EI's improved living conditions play a role in supposedly narrowing the differences in life expectancy between border- and non-border regions.

It is not only relevant to study this knowledge-gap from an academic perspective; it also encompasses a societal relevance for several reasons. First, besides the aforementioned goal of reducing economic and health differences, the EU is taking on action to boost border regions' socio-economic development and their integration (European Commission, 2017). However, this is not fully achieved yet (Olsson, De Smedt, & De Wispelarere, 2021), so studying border regions' health outcomes could help to better understand regional challenges and how to overcome those. Second, it is likely that the EU will expand even further over time (European Commission, 2020), so it is helpful to assess the influence of EI on convergence in life expectancy between border- and non-border regions for future applications. Lastly, on a more local level, policymakers wish to tackle regional inequalities (Janssen et al., 2016), so a greater understanding of border- and non-border regions' life expectancy trajectories is useful for the distribution of resources.

The study's focus will be on the Netherlands, which is a particularly interesting country because of its size. Compared to the rest of Europe, it is in the second quintile regarding life expectancy (Marmot et al., 2012). Seven out of twelve of its provinces border another country and despite being small, the Netherlands has dealt with significant mortality differences within its borders (Janssen et al., 2016). The average Dutch life expectancy has continuously increased over the last two decades (Mackenbach et al., 2011), which raises the question whether it has increased proportionally in every region.

1.2. Objective

Inequalities in health are persistent across and within European countries, which poses a major challenge for European Member States and their citizens. The current study aims to assess life expectancy trajectories of Dutch border- and non-border regions, to determine whether those have converged since the Maastricht Treaty. The Dutch border regions – adjacent to country borders – have likely benefitted directly from the European Integration's improvements, which correspond to the social determinants of health. Therefore, the additional objective is to determine the role of contextual factors in the trends of border- and non-border life expectancy trajectories. A greater understanding of this process could benefit the accession of future Member States and could contribute to the achievement of European- as well as local policy makers' goals to reduce health inequalities, thereby enhancing overall public health.

1.3. Research questions

In order to investigate the potential convergence of Dutch border- and non-border life expectancies and the role of improved living conditions since the European Integration, an overarching research question and two supporting sub-questions are formulated, which are presented below.

The current's study main research question is:

1. *How have the life expectancy trajectories of Dutch border- and non-border regions converged since the European Integration of 1992 onwards?*

Considering that the Dutch border regions are not an homogenous block, the first sub-question is:

i.) *Which spatial patterns can be distinguished in the development of the border regions' life expectancy trajectories compared to the non-border regions since the European Integration of 1992 onwards?*

To assess the role of contextual factors in these developments, the following second sub-question is formulated:

ii.) *What role do improved living conditions in border regions since the European Integration of 1992 onwards play in narrowing differences in life expectancy trajectories between border- and non-border regions?*

1.4. Structure of the paper

Chapter 1 covers the background (1.1), the objective (1.2), and the research questions (1.3) of the current study. In Chapter 2, the theoretical framework (2.1) , literature review (2.2), conceptual model (2.3) and the hypotheses (2.4) are presented. Chapter 3 introduces the research design (3.1), data (3.2), methods (3.3) and the ethical considerations (3.4). Then, in Chapter 4, the results are presented, divided into separate paragraphs; 4.1 on convergence in life expectancy trajectories, 4.2 on the spatial patterns and 4.3 on the contextual factors. Finally, Chapter 5 contains a summary of the main findings (5.1), their embeddedness in the literature (5.2), the interpretation of results (5.3), the study's limitations (5.4), recommendations for policy and research (5.5) and an overall conclusion (5.6). After Chapter 6's references, there are three appendices, which address the study region (Appendix I), a fixed effects panel regression on border regions only (Appendix II) and an additional analysis on the remaining life expectancy at age 65 (Appendix III).

2. THEORY

2.1. Literature review

As discussed in the introduction, none of the consulted studies specifically investigate convergence in border- and non-border regions' life expectancy (i.e. health) since the European Integration and the role of contextual factors during this process. Nonetheless, several studies are relevant to this topic, which are covered in this section.

Like the introduction stated, several studies denote national economic developments to be associated with EI (e.g. Illing, 2023; Padilla, 2020; Campos et al., 2019; Orlowski, 2020; Zhao et al., 2022). Economic development is associated with higher levels of education, slimmer risks of unemployment and better access to healthcare (Bělohradský & Glocker, 2019), which in turn contributes to improved health. Namely, health outcomes are affected by socioeconomic factors, lifestyle, environmental- and living conditions and the availability of healthcare (WHO, 2019). However, like Favell and Recchi (2009) note, the social effects of EI have yet to be studied more extensively. Moreover, Topaloglou et al. (2005) argue that the impact of EI on border regions deserves more attention. One exception is a study by Basboga (2020), which indicates that opening the borders to free movement results in a 2.7 percent increase in Gross Value Added (GVA) per capita in Europe's border regions. The author does not distinguish between countries, but rather groups them into three categories (EU member & not-yet-open border, EU member & open border and non-EU member & open border). Evidently, exact economic gains from EI could differ across European border regions, which is why it remains unclear how it has affected the Dutch border regions specifically.

To gain more knowledge on convergence in health across Europe, Hrzic et al. (2020) conducted a systematic review, in which seven studies are eventually included. The studies relying on beta convergence analyses do find convergence (e.g. Stańczyk, 2016; Jaworska, 2014), whereas the sigma convergence analyses find divergence in health between Europe's Member States (e.g. Spinakis et al., 2011). Hrzic et al. (2021) also studied the short-term consequences of European enlargement on mortality convergence combining Member States and NUTS 2 regions within Czechia, Hungary and Poland. They study life expectancies of 23 EU countries between 1990 and 2017 and assess the short-term convergence effects of the 2004 EU-enlargement. On a national level, the authors find mortality convergence, but on a regional level they do not. At this point, it remains unclear whether convergence has occurred, as it appears to depend on the type of analysis involved. Moreover, the studies discussed in this paragraph compare European countries, in which NUTS 2 is the most detailed level of analysis. Considering that the current study aims to understand convergence in life expectancy trajectories within the Netherlands, a more detailed level of analysis is preferred.

Studies on regional convergence in health are even more rare, particularly over a longer period of time. A few exceptions were found, such as Gächter and Theurl (2011). They study mortality data from over 2,000 Austrian regions between 1969 and 2004 and find evidence for beta-convergence within that period, which refers to the catch up of the less advantaged regions. The authors hypothesize that this convergence might be facilitated by central health policies, citizens' mobility and improved living conditions, but their study does not have the means to back this up empirically. A study conducted in Germany between 2005 and 2016 found that trends in life expectancy differ by income group and that not everyone benefitted the same from the general increase in life expectancy (Tetzlaff et al., 2020). In Spain, regional differences in health are studied between 2006, 2012 and 2017 (Zueras & Rentería, 2020). The results indicate that health differences converged up until 2012, but widened again in 2017. The authors hypothesize that some regions were hit harder by the 2008 economic crisis, in which the availability of health services was limited. Perhaps a bit outdated, but topic-wise the study of Groenewegen et al. (2003) is also quite informative. The authors assess regional healthy life expectancies for life expectancy at birth as well as the remaining life expectancy at age 65 in the Netherlands. They study the life expectancies of 27 regions in the year 1995, as well as the role of several social conditions. However, the study covers one year in time, so no statements can be made about changes over time nor convergence. The most relevant study to the current study is a study on regional mortality convergence in the Dutch context, by Janssen et al. (2016). The authors study 40 Dutch NUTS-3 regions within the period 1988 to 2009, and find evidence for beta-convergence. Their results thus indicate that the regions with the lowest life expectancy gained the most years of life, whereas the regions with the highest life expectancies gained the least. Even though

the authors do not recommend it themselves, taking regional contextual factors more prominently into account could allow to make (more) sense of any findings. For instance, the authors argue that the results seem to indicate that national trends had a similar effect on singular regions (p.103), which could be tested with regional explanatory variables.

On a regional level, it thus turns out that convergence in health can occur. However, the studies assess convergence in life expectancy across all regions within a country, rather than between border- and non-border regions. A study conducted in the United Stated does identify that the negative association between unemployment and mortality is stronger in urban- than in rural regions (Sameem & Sylwester, 2017), but that does not clarify the relationship between border- and non-border regions in the European context. At the same time, studies on border regions generally do not document economic- and health developments. The rising body of literature on border regions generally covers topics such as cooperation, governance and mobility (Makkonen & Williams, 2016). More specifically, scholars have studied shopping tourism (Szytniewski, Spierings, & van der Velde, 2016; Spierings & van der Velde, 2013), transnationalism (Strüver, 2005), emergency management (Princen, Geuijen, Candel, Folgerts, & Hooijer, 2014), police cooperation (Spapens, 2010; Fijnaut, 2016), healthcare cooperation (Gyelnik, 2016) and multidimensional integration (Durand & Decoville, 2019) in border regions. It thus remains unclear to what extent the life expectancy trajectories of border- and non-border regions have converged.

The introduction emphasised inequalities in health to be unjust (Eikemo et al., 2017). For instance, scholars denote unmet healthcare needs based on gender (Bryant, Leaver, & Dunn, 2009) and poorer health outcomes for minority ethnic groups (Launer, 2020). Health differences are not solely driven by individual characteristics; macrolevel conditions play a role in health differences across regions as well. For instance, higher local GDPs are associated with better health outcomes among Hungary's regions (Uzzoli & Szilágyi, 2009) and regional socioeconomic deprivation is linked to a larger gap in Czechia's regional health (Bělohradský & Glocker, 2019). It is argued that more attention should be drawn to the determinants of mortality convergence and that it would be relevant to take (more) explanatory variables into account (Hrzric et al., 2020; Gächter & Theurl, 2011). In their systematic review, Hrzic et al. (2020) distinguish two studies that do include determinants of health convergence: Maynou and Saez (2016) and Maynou, Saez, Bacaria and Lopez-Casasnovas (2015). However, the two studies generally note opposite directions of effects (e.g. on country public expenditure rate and regional youth male unemployment) and the majority of effects are not statistically significant. On a more regional level – like previously touched upon - Gächter and Theurl (2011) point to health policies, citizens' mobility and improved living conditions as potential explanations for regional convergence in health (which they do not empirically test). All in all, there is little agreement on determinants of regional convergence in health, particularly in relation to the European Integration.

The current study thus aims to perform an additional analysis covering contextual factors related to improved living conditions, such as migration, economic activity and population growth. National policies and conditions are applicable to all regions (Bělohradský & Glocker, 2019), so differing health expectancy trajectories are more likely related to different regional conditions. Consult chapter 3 for the current study's method section.

2.2. Theoretical framework

Before we move on, it is important to define the study's central themes: life expectancy, convergence, border region and European Integration, so it is clear what is meant by them throughout the study.

The measure 'life expectancy' refers to the average number of additional years that a survivor to a specific age will live beyond that age (Preston, Heuevline, & Guillot, 2001, p.38,39). In the current study, the main focus is on the life expectancy at birth ($e0$), which thus represents the average number of additional years that a new born can expect to live.

Regarding 'convergence', there are two types that can be distinguished: beta- and sigma convergence. The former indicates whether the life expectancies of lagging regions increased more than that of the more advanced regions, whereas the latter indicates whether cross-sectional differences have narrowed (Janssen et al., 2016; Hrzic, Vogt, Janssen, & Brand, 2020; Hrzric et al., 2021). The objective of the current study is to assess convergence in general; the type of convergence is of lesser importance. Therefore, in this study, convergence means that the populations' life expectancy trajectories are getting more similar over time (Hrzic et al., 2021, p.910), in this case

between border- and non-border regions.

The term 'border region' refers to a delimitated surface area alongside a particular boundary (Medeiros, 2019, p.1), which impacts the area at hand (Angelovič & Ištok, 2016, p.24). In the current study, the boundary is the border between the Netherlands and Germany as well as the border between the Netherlands and Belgium. Considering that the study's focus is on the Netherlands, this results into fifteen Dutch border regions. Consult Appendix I for the current study's area of interest.

'European Integration' is defined as a process in which i) new policy areas are at least partially regulated on the EU level (i.e. sectoral integration), ii) competencies are more often shared among Member States or delegated to independent supranational institutions (i.e. vertical integration) and iii) by the accession of new Member States, in which the EU expands territorially (i.e. horizontal integration) (Schimmelfennig & Rittberger, 2006, p.74).

2.2.1. Convergence-divergence framework

In order to understand whether and how Dutch border- and non-border regions have experienced converging life expectancies since the 1992 European Integration, it is important to grasp the general mechanism behind convergence in health. For this, Vallin and Meslé's (2004) framework on convergence in mortality is adopted. The measure life expectancy is directly affiliated with mortality and it is equal to the average age of death (Preston et al., 2001). Consequently, even though the convergence-divergence framework is originally on convergence in mortality, it is readily applicable to convergence in life expectancy. The convergence-divergence framework is an addition to Omran's (1971) epidemiological transition theory on changing patterns of health and disease and their determinants, which is challenged by regions that are unable to get past the stages of the transition. Vallin and Meslé (2004) divide countries into two groups: the vanguard- and the laggard group. The former refers to pioneering countries that have experienced and adopted improvements that contribute to reducing mortality, such as new medical technology, improved health behaviours, better public health policies and higher living standards. The latter refers to lagging countries that are catching up at different paces. The authors emphasize that the speed of catching up depends on the availability of new health relevant tools and innovations and the country's ability to implement those. Therefore, a country's economy, political- and social structure are important assets to allow improvement (Meslé & Vallin, 2017).

This mechanism ties in with the social determinants of health. These factors are known to influence health outcomes, and consist of determinants such as socioeconomic status, education, living conditions, employment, social networks as well as the quality and availability of healthcare (Artiga & Hinton, 2018). These conditions thus improve the lives people are able to lead (Marmot et al., 2012). For instance, economic performance in the sense of productivity and participation in the labour force are related to population health; a region's socioeconomic status can account for a difference of up to four years in life expectancy (Bělohradský & Glocker, 2019), GDP per capita and educational levels are able to explain up to almost 83% of the variance in life expectancy at birth across Europe (Bilas, Franc, & Bosnjak, 2014), and increasing healthcare spendings are found to be related with decreasing health inequalities (Mackenbach et al., 2019).

Considering that the convergence-divergence framework groups countries in a pioneering or a laggard group (Vallin & Meslé, 2004), it is in essence an international approach. However, a similar mechanism can be expected on a regional, within-country level. Take for instance the previous section's regional studies on convergence in health, which generally find convergence to a certain degree (e.g. Janssen et al., 2016; Gächter & Theurl, 2011; Tetzlaff et al., 2020; Zueras & Rentería, 2020). None of the authors explicitly refer to Vallin and Meslé's (2004) convergence-divergence framework, but some do point to several developments that could be associated with converging health outcomes. To refresh: Gächter and Theurl (2011) hypothesized that the convergence they found could be explained by central health policies, citizens' mobility and improved living conditions. In the Czechian context, Bělohradský and Glocker (2019) argued that socioeconomic inequalities drive health inequalities. These suggestions tie in with the assets that allow the catch up of the laggard regions, as proposed by Vallin and Meslé (2004). From a regional viewpoint, this would mean that the Dutch non-border regions can be considered the country's vanguards, whereas the Dutch border regions can be considered the country's laggards that are catching up at different speeds. Whether such living conditions improved in the Dutch border regions and how these could have affected the catch up of these regions is covered in the next paragraph.

2.2.2. Core-periphery model

The core-periphery model can help to get a better understanding on how border regions could have developed since the European Integration. The core-periphery model was introduced by Krugman (1991) and states that regions can be identified as being either core or periphery. Core regions are industrialized regions, which make modest use of the land. Peripheral regions are concerned with agricultural production, characterized by intensive use of the land (Krugman, 1991, p.485). Manufacturing firms tend to settle in regions with a larger demand; the core regions. These firms benefit from being in close proximity to core regions, as this nearness results in lower transportation costs. Hence, it is more desirable for firms to concentrate in core regions, while the peripheral regions end up as suppliers of labour to the core. Consequently, core regions have much potential for innovation and development, whereas peripheral regions face lagging growth or even stagnation (Moore, 1994). This dichotomy affects the opportunities of such regions, in which the periphery is faced with unemployment, the risk of impoverishment (Szul, 2006), lacking infrastructure and little supply of jobs and services (Bernard, 2019). Just like manufacturers, health facilities tend to locate in core regions, considerably reducing the availability of (health) services in periphery regions (Murray, 2004).

Most scholars who adopt the core-periphery model take a static approach (e.g. Plechanovová, 2012; Magone, Laffan, & Schweiger, 2016; Kersan-Škabić, 2020), so once regions are identified as either core or periphery, it is not studied how this classification could change over time. Campos and Macchiarelli (2021) are an exception. The authors aim to study dynamics of core and periphery in Europe. Their results indicate that there is a decreasing gap between core and periphery in the context of the EU, likely resulting from the adoption of the same currency and increasing competition. In fact, Leonardi (2006) even argues that peripheral countries have developed faster than core countries did, in which socio-economic disparities between core and periphery have narrowed. Even though both studies suggest that periphery countries have been catching up to the core ones, no studies appear to investigate this trend on a regional scale.

The European Union's (EU) border regions account for 40 percent of its land mass and 30 percent of its inhabitants (European Commission, 2017). Compared to the other European nations, The Netherlands could be considered a core-country (Belke, Domnick, & Gros, 2017). However, from a national perspective, not every Dutch region is necessarily a core-region too. More specifically, before the Maastricht Treaty was put into place, all border provinces in the Netherlands belonged to the Dutch periphery (Nijkamp, 1993). From a Dutch viewpoint, the relatively disadvantaged border regions, - as discussed in the introduction - could thus be viewed as peripheral regions facing stagnation (Krugman, 1991).

The previous sections already touched upon positive outcomes that can be attributed to the European Integration. Besides Basboga (2020), a research gap prevails on its precise impact in border regions, but it is likely that border regions experienced improvements since 1992. As discussed in the introduction, the European Integration led to the principles of free movement of capital, goods, services and people, the availability of funds and the right to equal treatment in every Member State (Favell & Recchi, 2009). Moreover, cross-border cooperation has amplified, for example in healthcare. These cross-border health projects involve factors such as education and training, patient care, prevention and disaster control (Brand, Hollederer, Wolfj, & Brand, 2008). One could argue that country borders have gotten less of a barrier since the European Integration, which results in lower transportation costs. Namely, where border regions used to be the outer corners of their nations far away from the country's core, their cross-border connectedness now allows them to share opportunities and services with each other. On an intra-EU level, it turns out that increased trade between core-periphery as well as between periphery-periphery led to stronger improvements than trade between core-core (Egger & Pfaffermayr, 2013). Something similar could have happened on a regional level between border-non-border and border-border regions. Consequently, border regions' citizens can cross the border for activities including work, tourism, (health) services, shopping and leisure (Järv, Aagesen, Väisänen, & Massinen, 2022), making border regions' citizens less confined to their area of residence (Carling, Erdal, & Talleraas, 2021). The term 'transnational medical travel' came into existence, to express citizens' temporary movement across national borders to receive healthcare (Ormond & Lunt, 2019, p.4180). These developments have contributed to border regions' increased social interactions and -flows (Durand & Decoville, 2019), an increased population share (Gouveia, Correia, & Martins, 2020) and improved transport routes (Löfgren, 2008). The cross-border cooperation in health is argued to decrease

border regions' disadvantages, strengthen their integrated development and ultimately improve the local population's living conditions (Brand et al., 2008). Consequently, living in a border region is viewed upon as an opportunity rather than a constraint (European Commission, 2015).

There is little concrete data available on the situation of Dutch border regions since 1992, but there are a few promising signs. Regarding the Dutch border regions, the Dutch National Statistical Office, CBS (2017) has conducted a study on the labour market in the border region with Belgium, which indicates that almost 41,000 Belgian border commuters ("grenspendelaars") cross the Dutch border for work, whereas 12,000 Dutch workers cross the Belgium border. The Dutch regions "Zuid-Limburg" and "Zeeuws-Vlaanderen" host a particularly high share of Belgian commuters. The Statistical Office of North Rhine Westphalia studied the border labour market in the cross-border region of the Netherlands and Germany (Statistik kompakt, 2018), and finds that around 43,000 Germans cross the country border for work, compared to 9,000 Dutch border commuters. There is more influx that outflux of commuters on the German as well as the Belgian side, which would imply that the Dutch border regions benefitted from these population flows. This is in line with the increased social interactions- and flows in border regions (Durand & Decoville, 2019), making Dutch, Belgian and German citizens less confined to their areas of residence. Furthermore, the cross-border cooperation on the German-Dutch, as well on the German-Dutch-Belgian border are very active in the health sector, even though the cross-border region of the Northern Netherlands with North-Western Germany lacks behind and did not have an active working group in health while the others already did (Brand et al., 2008, p.249). A better cross-border cooperation in healthcare would also make transnational medical travel more accessible, further enhancing citizens' movements across borders (Järv et al., 2022). Therefore, the Dutch border regions do not necessarily need to keep providing to the country's core regions in the West; "De Randstad" (Knaap & van der Wall, 2002, p.23, Figure 4) and get opportunities to obtain more core-like characteristics themselves.

2.3. Conceptual model

Despite the literature review's overview of studies on the European Integration's (local) consequences, cross-border regions, cross-national- and regional convergence in health and a few on their potential determinants, the research gap as presented in the introduction prevails. More specifically, as none of the studies compare border- and non-border regions in health convergence, it remains unclear whether life expectancy trajectories between Dutch border- and non-border regions have converged since the European Integration and what the role of contextual factors (i.e. improved living conditions) has been during this process. In order to derive hypotheses on these research questions, two theories are combined in a complementary matter. The main mechanism will be summarized below.

First, it can be argued that the international approach of the convergence-divergence model of mortality (Vallin & Meslé, 2004) is also applicable to a regional level. This would mean that the Dutch non-border regions are viewed as the country's pioneering vanguards, whereas the Dutch border regions can be considered the country's laggards that are catching up at different speeds. In line with the convergence-divergence framework, improved living conditions (e.g. medical technology, health behaviours, public health policies and living standards) would allow the traditionally lagging Dutch border regions to catch up with the country's non-border regions.

Second, The main argument of Krugman's (1991) core-periphery theory is that it is the most desirable for firms to settle within core regions, due to lower transportation costs. However, there is a reason to assume that the classification of the theory into core and periphery is not necessarily static, as regions can change over time. From a Dutch perspective, this would thus mean that the initial peripheral border regions experienced improvements from the European Integration, as country borders have gotten less of a barrier. Instead of staying the relatively disadvantaged outer corners of their countries, border regions have become important locations to freely cross the border for activities including work, tourism, (health) services, shopping and leisure (Järv, Aagesen, Väisänen, & Massinen, 2022), they can demand equal treatment and cross-border cooperation is believed to improve living conditions for the local population. Basboga (2020) found that these developments are associated with improved economic conditions in European border regions. In the Dutch case, the border regions host a relatively large amount of commuters from Belgium (CBS, 2017) and Germany (Statistik kompakt, 2018) and its cross-border cooperation is generally very active in the health sector (Brand et al., 2008), presumably improving Dutch border regions' living conditions.

This reasoning is visualised in Figure 1's conceptual model. First, the European Integration is hypothesised to improve the Dutch border regions' living conditions, which ties in with the core-periphery model (Krugman, 1991). Then, these improved living conditions would improve the situation of border regions, hence narrowing the gap between the border- and non-border regions' life expectancies. This is in line with the convergence-divergence framework (Vallin & Meslé, 2004), adopted on a regional level. The bottom arrow indicates the time element, which covers the time-period from 1992 onwards. Keep in mind that the arrows do not imply causality, but a potential association.

Figure 1. Conceptual model, own visualisation.

2.4. Hypotheses

The theory section indicated that life expectancies have increased in general (Scholz, 2020; Tetzlaff et al., 2020), making it unlikely that Dutch border- nor non-border regions' life expectancies decreased between 1988 and 2021. Regarding the main research question on convergence in life expectancy between Dutch border- and non-border regions since 1992, the conceptual model (Figure 1) indicates that life expectancy trajectories between the two would narrow. More formally phrased, the first hypothesis would be:

1. *On average, differences in life expectancy trajectories between Dutch border- and non-border regions have narrowed more from 1992 onwards than they did between 1988-1991, suggesting convergence in life expectancy since the European Integration.*

According to CBS (2017), "Zuid-Limburg" and "Zeeuws-Vlaanderen" are common destinations for commuters from Belgium. "Midden-Limburg" might also experience relatively many improvements, as it – just like "Zuid-Limburg" – borders two countries instead of one. Regarding cross border cooperation, Brand et al. (2008) argue the cross-border region of the Northern Netherlands with North-Western Germany is less advanced in their cooperation on healthcare. Considering that the country's core is located in the West, the following hypothesis on the first sub-question can be formulated:

a) *On average, life expectancy trajectories between border- and non-border regions have converged more in border regions closer to the country's core (i.e. Southern and/or South-Western border regions) than in regions further away from the country's core (i.e. Eastern and/or North-Eastern border regions) since the European Integration of 1992 onwards.*

The European Integration is found to have contributed to economic developments (e.g. Basboga, 2020; Illing, 2023; Padilla, 2020; Campos et al., 2019; Orlowski, 2020; Zhao et al., 2022). Both the convergence-divergence framework of mortality (Vallin & Meslé, 2004) and the social determinants of health (i.e. socioeconomic status, educational level, employment, living conditions, social support networks and access to healthcare (Artiga & Hinton, 2018)) suggest that health improvements are driven by improved living conditions. However, scholars hardly take the determinants of mortality convergence into account in their studies (Hrzic et al., 2020). Considering that productivity and participation in the labour force and socioeconomic status are linked with health (Artiga & Hinton, 2018) and narrowing life expectancy differences (Bělohradský & Glocker, 2019; Bilas et al., 2014), the catch up of border regions in GDP per capita and the relative number of employed citizens could be related with narrowing life expectancies between border- and non-border regions. Furthermore, healthy people tend to migrate to places with more opportunities (Gächter & Theurl, 2011), so an increasing number of arriving migrants would mean an influx of relatively healthy citizens, reflecting the attractiveness of the area. In addition to that, an increasing population size could thus be viewed as an asset to narrow health

differences. Consequently, the population share in border regions increased following the European Integration (Gouveia et al., 2020) while they traditionally faced population decline (Young, 2010). Moreover, it can be argued that the relative share of elderly citizens reflects less opportunities within a region, as the healthy people move away and the people in worse health are left behind. Take for instance the ageing populations that border regions initially faced (Anđelković-Stoilković et al., 2018). Hence, a greater share of people aged 65 and over is likely to widen the gap in life expectancy between border- and non-border regions. This comes together in the following hypothesis on the second sub-question:

b) On average, greater GDP per capita, employment levels, in-migration and population growth in border regions have a narrowing effect on differences in life expectancy trajectories between border- and non-border regions, whereas a greater share of people aged 65 and over in border regions widens the differences in life expectancy trajectories between border- and non-border regions since the European Integration of 1992 onwards.

3. DATA AND METHODS

3.1. Study Design

This study is a longitudinal, quantitative macrolevel analysis, relying on secondary data. The objective is to investigate whether there has been convergence between Dutch border- and non-border regions' life expectancy trajectories from 1992 onwards, as the Maastricht Treaty is considered to have amplified the European Integration. In addition, the role of contextual factors in these developments in assessed. For this study, a quantitative approach is better suitable than a qualitative one, as many cases (of death) need to be investigated. It is less important to understand deeper meanings, perceptions and values, which is the focus of qualitative research (Hennink, Hutter, & Bailey, 2020). The study assumes that an objective reality exists (realist ontology), which can be understood through observations (representational epistemology). Hence, the positivist paradigm assumes that the mechanisms of (social) life can be explained (Aliyu, Bello, Kasim, & Martin, 2014).

In order to make statements about the overarching research question, abridged period life tables by sex will be created, in line with Preston et al. (2001). The life expectancies will be computed separately for males and females, because there are sex differences in life expectancy, due to differing mortality patterns (Nathanson, 1984; Bergeron-Boucher, Alvarez, Kashnitsky, & Zarulli, 2022; Austad, 2006; Zarulli et al., 2017; Luy & Gast, 2014; Luy, 2003), health (risk) behaviours (Noble, Paul, Turon, & Oldmeadow, 2015; Mechanic & Cleary, 1980; Dawson, Schneider, Fletcher, & Bryden, 2007; Ek, 2013) and responses to external health challenges, for instance in their willingness to adhere to the COVID-19 regulations (Galasso et al., 2020). These life expectancies will in turn be plotted in line graphs, to be able to determine whether the border- and non-border life expectancy trajectories have converged on average since 1992.

The first sub-question's spatial patterns will be assessed by maps. Maps make spatial patterns more readable, take for example Schmertmann (2008), who mapped spatial patterns of Brazil's fertility very clearly. Therefore, maps of all 40 COROP regions over time will be created.

The second sub-question on the role of contextual factors is covered with a fixed effects panel regression for either sex, which analyses the effect of narrowing differences in the explanatory variables between border- and non-border regions on narrowing differences in life expectancy between border- and non-border regions. Panel regression relies on cross-sectional, longitudinal data, which means that the same entities – in this case regions - are studied over time (Zulfikar, 2018). There are two types of panel regression: the fixed effects- and the random effects model. The fixed effects model assumes that the effects of unobserved variables are fixed (i.e. constant), whereas the random effect model assumes that these effects are not (Zulfikar, 2018; Brüderl & Ludwig, 2014). A fixed effects panel regression is thus able to account for structural region-specific characteristics, such as cultural influences and healthcare systems, which would have resulted in biased coefficients in regular (multiple) regression analyses (Brüderl & Ludwig, 2014). This is particularly suitable considering the relatively few independent variables of the current study (see paragraph 3.2), so unobserved constant influences on narrowing life expectancy differences between border- and non-border regions can now still be accounted for. Moreover, fixed effects panel regression investigates within-changes over time (Brüderl & Ludwig, 2014), allowing to investigate narrowing differences in life expectancy between border- and non-border regions from 1992 onwards by changes over time within the regions. The research questions, their aims and their corresponding analyses are summarized in Table 1. Paragraph 3.2 elaborates further on the current study's data.

Table 1. Overview of the current study's research aims and analyses.

	Aim	Analysis
RQ1	Investigate convergence in life expectancy trajectories between border- and non-border regions from 1992 onwards.	Line graphs of (average) life expectancies of border- and non-border regions.
RQ1a	Investigate spatial patterns in life expectancy of all COROP regions over time.	Maps of the 40 COROP regions at multiple points in time.
RQ1b	Assess the role of contextual factors in convergence in life expectancy between border- and non-border regions from 1992 onwards.	Fixed effects panel regression on narrowing differences in border- and non-border regions' life expectancies.

3.2. Data

The current study's level of analysis is on a NUTS-3 level, which is the most detailed level of analysis in the EU's Nomenclature of territorial units for statistics (NUTS) classification (Eurostat, 2020). These regions are referred to as COROP regions in the Netherlands (Janssen et al., 2016; CBS, 2017), see Appendix I for an overview. This study is on a COROP-level instead of a municipal level for two reasons. First, there have been many municipal reallocations over time, complicating the analysis. In 1900 there were over a 1,000 municipalities, which shrunk to 483 in 2004 (Lisci-Wessels, 2004), to 345 in 2022 (CBS, 2021). Second, especially less densely populated municipalities yield the risk of too little cases (of death) per age group, resulting in less reliable calculations. Now, the required data per analysis will be presented.

For the first analysis – on convergence in life expectancy – population- and mortality counts are required to compute regional life expectancies. The population of interest are Dutch males and females of all ages, who resided (or passed away) in the Netherlands within the study period of 1988 to 2021. In order to create abridged life-tables, mid-year population counts are needed (Preston et al., 2001). However, CBS's mid-year population counts (2022a) are not suitable for this study. CBS (2022a) obtains the average population counts by adding half of the population of January 1st and half of the population of December 31st together. This in itself is not a problem, but it turns out that for age 0 only the first half of the population is included for all years in time, all regions and both sexes. An example: Oost-Groningen has 607 male infants on January 1st of 2016 and 656 male infants on January 1st of 2017. Intuitively, in 2016 the average male population of age 0 in Oost-Groningen would be somewhere around 630. However, CBS's mid-year population count of 2016 is 303.5 (half of 2016's 607), which implies that half of the infants passed away. Of course, a fraction of infants die, but infant mortality is generally low in the Netherlands, in which 380 infants died within their first week of life in 2010 (Engelberts, 2013). CBS was contacted about this, and responded that this was a deliberate decision to account for the children under 1 who would participate – on average - only 6 months in the year. However, as long as those children did not die, they would still belong to the age category 0-1, so CBS's calculation results in a substantial overestimation of infant death, as the number of deaths are now divided by a much smaller population size. In turn, this yields the risk of an underestimation of life expectancy at birth. Therefore, the mid-year population counts by sex and year will be computed manually over the whole period of 1988-2021. This will be done by taking the averages of CBS's (2022a) January 1st population counts by year of age, as this is the only population measure available. Consequently, the population counts of two consecutive years will be summed and divided by two, to get sex-specific artificial regional mid-year population counts by year of age per year in time. Even though the main focus is on convergence in life expectancy from 1992 onwards, it would be tricky to make statements about the role of the European Integration without information on the situation prior to 1992. Therefore, data will be extracted from the first available year onwards, which is the year 1988 (2022a). Next, these are summed into 5-year age groups, as CBS's (2022b) mortality data is not available by year of age. This results in the following age groups: 0, 1-4, 5-9, (…), 95+.

Following the study of Janssen et al. (2016), the mortality counts will not distinguish between causes of death; the so-called 'all-cause mortality' counts. The all-cause mortality five-year age group mortality counts by sex originate from CBS (2022b), which cover all 40 regions by year. The mortality data is available up until 2021, which is why the analysis covers 1988-2021. The secondary data used in this study to compute the life expectancies have been collected by the Dutch statistical office, CBS (2022a; 2022b). Population data originate from population registers, making them of good quality (Janssen et al., 2016).

For the second analysis – on the spatial patterns - the regional life expectancies of the first analysis will be visualised on maps. Therefore, the only additional data to be gathered are data to allow to map the regional life expectancies. More specifically, Eurostat's (2021) shapefile of all Member States and NUTS levels is obtained. From this larger file, the Netherlands' NUTS level 3 is extracted, which can be used for each year of interest and for males as well as females.

Finally, for the third analysis – on the role of contextual factors – several explanatory variables will be included. The theoretical section of this study identified multiple factors that could be of relevance for this analysis. However, there is little data available that: i) covers the whole period of interest and ii) is on a NUTS-3/COROP level. The contextual factors that will be included in this study are in line with what Smolińska, Józefowicz, and Bednárová (2022) consider social-development variables (see their study's p.514). More specifically, data on: GDP per capita (ARDECO, 2023a), employment (ARDECO, 2023b), in-migration (2022c) and population growth (2022c) will be included. Additionally, a variable covering the time period (pre-Maastricht Treaty, short-term effect and long-term effect) will be created. For the short-term effect, Hriz et al. (2021) are used as a reference, as they consider the short-term effects of European enlargement on mortality convergence to be three years (in their case 2004-2007). Next to that, another variable will be constructed that covers the percentual share of people aged 65 and over. This is manually computed by taking the sum of the population counts of age group 65–69 onwards by sex, region and year, dividing this by the sum of all age groups and eventually multiplying it by 100%. Table 1 gives an overview of the operationalisation of the fixed effects panel regression's variables.

Table 2. The operationalisations of the current study's fixed effects panel regression analysis.

Variable	Explanation/operationalisation
e0 male/e0 female (own calculations based on CBS, 2022a; CBS, 2022b)	Continuous variable for life expectancy at birth per region per year by sex.
Time period (own constructed variable)	0 = Pre-Maastricht Treaty (1988-1991), 1 = Short-term effect (1992-1995), 2 = Long-term effect (1996-2021).
GDP per capita (ARDECO, 2023a, code SNETD)	Continuous variable for GDP per capita in euros. However, ARDECO does not have a codebook on this dataset, so there is no additional information available.
Employment in thousands (ARDECO, 2023b, code SHVGDP)	Continuous variable for the number of employed people divided by 1000. However, ARDECO does not have a codebook on this dataset, so there is no additional information available.
Relative in-migration (CBS, 2022c)	Continuous variable for the number of people moving in from abroad or another Dutch region per thousand of the average population (‰).
Relative population growth (CBS, 2022c)	Continuous variable for the overall growth of the population per thousand of the Jan 1st population (‰).
Aged 65+ male/aged 65+ female (own calculations based on CBS, 2022a)	Continuous variable for the percentage (%) of the population aged 65 and over.

In order to get a better understanding on the distribution of these variables, Table 3 presents their descriptive statistics. The top box contains the border regions' descriptives, the second box contains the non-border averages. For the panel regression, variables will be constructed that denote the difference between each border region's value and the corresponding non-border average (see section 3.3). Regarding the descriptives, the mean, standard deviation, median, minimum, maximum and number of cases are presented. Even though there are more non-border regions (25) than there are border regions (15), they have substantially less observations as their averages were taken for each year. Hence, the descriptives of the non-border values cover differences over time, rather than between regions over time. The categorical variable for the time period at hand indicates that 11.76% of observations belong to the pre-Maastricht period; 11.76% belongs to the short-term period (1992 – 1995) and 76.47% is part of the long-term period (1996 – 2021). Considering that border regions and non-border regions are studied

over the exact same period in time, their relative distributions remain identical. Now, the most relevant descriptives will be addressed.

In general, border regions tend to be worse off than the non-border regions; they have lower life expectancies for males ($e0$ male border = 76.98; $e0$ male non-border = 77.46) and females ($e0$ female border = 81.69; $e0$ female non-border = 82.01), lower GDP per capita (GDP per capita border = € 26,534.97; GDP per capita non-border = €29,609.90), lower employment (employment border = 187.67; employment non-border = 217.13), lower in-migration (border in-migration = 44.43‰, non-border in-migration = 49.09‰), lower population growth (border population growth = 2.38‰; non-border population growth = 5.82‰) and higher shares of citizens being aged 65 and over in males (border 65+ male = 14.54%; non-border 65+ male = 13.21%) and females (border 65+ female = 18.53%; non-border 65+ female = 17.14). The lowest life expectancy values are approximately two years lower in border regions than they are in non-border regions (minimum male border $e0$ = 72.39, minimum non-border male $e0$ = 74.18; minimum border female $e0$ = 78.46; minimum non-border female $e0$ = 80.38). However, the medians of life expectancy are relatively similar between border- and non-border regions (median male border $e0$ = 77.06; median male non-border $e0$ = 77.53; median female border $e0$ = 81.70; median female non-border $e0$ = 81.89). This is likely due to the non-border regions already being average values, so their outliers are evened out. Regarding GDP per capita, the median measure indicates that 50% of the border region citizens earn less than €26,795.26 and 50% earns more than that. In the case of non-border regions, the median is €31,036.89, which suggests that the average citizen in a non-border regions earns over 4,000 euros more than a border region citizens does. Another interesting descriptive is that the minimum value on population growth is never negative in non-border regions, whereas the lowest value in border regions is -14.90‰. This implies that border regions have a higher tendency to experience population decline than non-border regions do. Table 3 presents all current study's descriptives.

Table 3. Univariate descriptive statistics of the current study's fixed effects panel regression variables.

	Variable	Mean(SD)	Minimum	Median	Maximum	n
Border	e0 male	76.98(2.33)	72.39	77.06	81.27	510
	e0 female	81.69(1.37)	78.46	81.70	84.95	510
	Time period[a]	11.76% (pre-Maastricht Treaty, 1988-1991) 11.76% (short-term, 1992-1995) 76.47% (long-term, 1996-2021)				510
	GDP per capita	26534.97(9235.07)	8150.28	26795.26	57379.11	510
	Employment in thousands	187.67(117.22)	15.54	170.20	482.18	510
	Relative in-migration (‰)	44.43(10.65)	27.20	42.80	158.70	510
	Relative population growth (‰)	2.38(4.34)	-14.90	2.80	15.20	510
	Aged 65+ male (%)	14.54(3.89)	8.25	13.63	24.66	510
	Aged 65+ female (%)	18.53(3.45)	12.00	18.08	28.11	510
Non-border	μ e0 male	77.46(2.29)	74.18	77.53	80.87	34
	μ e0 female	82.01(1.24)	80.38	81.89	83.80	34
	Time period[a]	11.76% (pre-Maastricht Treaty, 1988-1991) 11.76% (short-term, 1992-1995) 76.47% (long-term, 1996-2021)				34
	μ GDP per capita	29609.90(8525.49)	15166.10	31036.89	42994.14	34
	μ Employment in thousands	217.13(29.16)	159.18	225.58	261.72	34
	μ Relative in-migration (‰)	49.09(4.81)	44.04	47.44	62.17	34
	μ Relative population growth (‰)	5.82(1.94)	2.16	6.03	8.67	34
	μ Aged 65+ male (%)	13.21(2.78)	10.33	12.00	18.76	34
	μ Aged 65+ female (%)	17.14(2.00)	15.01	16.01	21.39	34

[a] = Distributional shares are presented for categorical variables.

3.3. Methods

To iterate, the methodology can be divided into three parts: the first part to investigate convergence in border- and non-border life expectancies using line graphs, the second analysis to assess spatial patterns using maps and the third analysis to assess the role of contextual factors by doing a panel regression for either sex.

The first analysis will help to answer the overarching research question. In this part, regional life expectancies per year will be computed with abridged life tables by sex, in line with Preston et al. (2001). More specifically, the (manually calculated) mid-year population- and mortality counts by sex (CBS, 2022a; CBS, 2022b) are the data's nNx and nDx respectively. From there, each element of the life table is computed. First, the death rate in the cohort between the ages x and $x+n$ (nmx) is computed, which is obtained by dividing the matrix of the death counts (nDx) by the matrix of the population counts (nNx). The length of the interval (n) corresponds with the number of years covered by the age groups, which is generally 5, except for age 0 ($n=1$), age group 1-4 ($n=4$) and age group 95+ ($n=\infty$). Regarding nax - the average number of person-years lived in the interval x to $x+n$ by those dying in the interval - the calculation follows the rule of thumb, which is dividing every age group's n-value by 2. Instead of the usual 2.5, this results in the values 0.5 and 2 for the first two age groups. Then, the probability of dying between ages x and $x+n$ (nqx) is computed by $\frac{n*nmx}{1+(n-nax)*nmx}$ for every age group. Considering that everyone dies at one point, the last age group (95+) gets value 1.00. Next, npx denotes the probability of surviving from age x to age $x+n$ which is calculated as 1 minus the age group's nqx-value. Similarly, the value of the last age group (95+) is 0.00, because once the probability to die is 1, the probability to survive equals 0. The next measure is lx, which represents the number left alive at age x. The first value of lx ($l0$) is generally 100,000. The following lx-values are computed by multiplying the previous lx and npx values. Or denoted differently, $lx+n = lx * npx$. After that, the number dying between ages x and $x+n$ (ndx) is computed, by subtracting the $x+n$'th lx-value from the lx-value of the current age group. The measure nLx in turn represents the person-years lived between ages x and $x+n$. It is calculated by $(n*lx+n)+(nax*ndx)$. In the case of age group 95+, it is computed a bit differently, namely; $\infty Lx = \frac{lx}{\infty \mathrm{mx}}$. From there, Tx can be calculated, which stands for the person-years lived above age x. Therefore, the sum is taken of the Lx-values of all age groups starting from the current age group onwards. Lastly, ex - the expectation of life at age x - can be computed. This is done by dividing Tx by the corresponding lx. From the ex-values, the first row now represents the life expectancy at birth, as this is the life expectancy at age (group) 0. These values will be the main assets to answer the current study's research questions. The values are selected and transported into a new Excel file for each sex. The Excel file contains the following variables: Region_ID (the name of the region), NUTS_ID (the statistical code of the region, e.g. "NL225" for "Achterhoek"), Border_region (a dummy variable for whether a region is a border region; 0 = non-border region, 1 = border region), $e0$ (the life expectancy at birth) and Year (the corresponding year in time).

The second analysis does not require major additional methodological steps, aside from what has already been discussed in the previous paragraph. The line graphs of the previous analysis allow to determine whether the regional patterns are relatively constant. These are indeed quite stable, so it suffices to map several points in time, rather than every year of 1988–2021. In order to have intervals of similar length, four maps will be created. Consequently, the results section (4.2.) presents the maps of the years 1988, 1999, 2010 and 2021. All legends will contain 5 quintiles, from lowest to highest life expectancy, which will help to determine the spatial patterns within the Netherlands and, most importantly, between the border- and non-border regions.

Finally, the third analysis aims to gain more insight into the contextual factors associated with narrowing differences in life expectancy between border- and non-border regions in the Netherlands between 1988 and 2021. Considering that the goal is to investigate these narrowing differences, having the regular life expectancy variable as the dependent variable is not suitable. Hence, this variable would denote the influence of an increase in the contextual factors on life expectancy, which could either (significantly) increase or decrease, rather than converge. Therefore, the current study's panel regression analysis will concern differences between border- and non-border regions on the variables. More specifically, it will be assessed whether a narrowing difference between border- and non-border regions

in the contextual variables is able to narrow the difference between border- and non-border regions' life expectancies. In order to do so, non-border averages by year are computed for every variable. Then, the border regions' values are subtracted from these averages, resulting in the difference between border- and non-border regions. Even though it makes sense theoretically to perform a fixed effects panel regression, it can also be tested empirically. One way to determine whether a fixed- or random effects panel regression is preferred for this study, is to run the Hausman Test. When the test comes back statistically insignificant ($p>0.05$), the random effects model is the most appropriate model, when the test comes back statistically significant ($p<0.05$), the fixed effects model is the most suitable option (Zulfikar, 2018; Raharjo, Hakim, Manurung, & Maulana, 2014). For the current study, the Hausman Test comes back statistically significant for both males and females (Male chisq = 38.386, $p<0.001$; Female chisq = 20.804, $p = 0.004$). Therefore, the analysis will be a fixed effects panel regression. For the panel regression, the identifier variable is "NUTS_NAME" and the time-variable is "Year". Not surprisingly, the dependent variable of each panel regression will be the difference between border- and non-border regions' life expectancy at birth. The main reason for doing two analyses is that – except for the share of people aged 65 and over – the explanatory variables are not by sex, while the life expectancy values are available for males and females. Therefore, the same values for GDP per capita, employment in thousands, relative in-migration and relative population development will be used in either panel regression. The panel regression will be a stepwise panel regression, in which each variable is added sequentially per model. By doing so, the amount of explanatory power of each covariate on narrowing differences in life expectancy between border- and non-border regions can be assessed. In the first model, the only independent variable will be the time period at hand. Then in model 2, the difference in GDP per capita between border- and non-border regions is added. The difference in employment per thousand between border- and non-border regions will be included in the third model. After that, the fourth model will be supplemented by the border- and non-border difference in relative in-migration. The fifth model adds the relative population growth. Finally, the share of people aged 65 and over is added in the sixth model.

All calculations and visualisations are done in R studio, version 4.2.3, which is an integrated development environment for the statistical software R (R Core Team, 2023). The reason for working with R is twofold. First, R is able to produce reproducible reports (van der Loo & de Jonge, 2012), which is of great relevance in terms of transparency and reproducibility. Second, there is a wide range of packages available in R (van der Loo & de Jonge, 2012), which are relevant to achieve the current study's objectives. The R-scripts of the current study are available on request.

3.4. Ethical considerations

As touched upon, this study does not collect its own data, but relies on macro-level data. This data does not reflect individual identifiers, so anonymity is ensured. If this study would have been on a municipal level, deaths could be traceable to specific individuals, but as the focus is on the larger COROP-regions, this is not a major concern. Furthermore, the study design is quantitative rather than qualitative, so there is no direct influence of the researcher on the data. Considering that the study's paradigm is in essence positivist, the role of the researcher is to gather data and interpret it objectively. Hence, the current study does not hold any noteworthy ethical constraints.

4. RESULTS

4.1. Life expectancy trajectories

In order to answer the overarching research question on convergence in life expectancy trajectories between border- and non-border regions from 1992's Maastricht Treaty onwards, Figure 2 and 3 are presented. The figures contain the average trend of non-border life expectancy (blue) and border life expectancy (red) by sex. The Y-axis represents the life expectancy at birth in years and the X-axis includes the years 1988 until 2021. The dashed line denotes the start of the European Integration following 1992's Maastricht Treaty. The line graphs indicate three findings: increasing life expectancies, no clear sign of convergence and relatively small differences between the average border- and non-border life expectancies. These observations will now be elaborated in more detail.

In general, border- and non-border life expectancies increased between 1988 and 2021, for males and females. As one can see on Figure 2 and 3, both the blue line (non-border region average $e0$) and the red line (border region average $e0$) show an increasing trend. Without distinguishing between border- and non-border regions, the male life expectancy has increased from approximately 74 years in 1988 to approximately 79 years in 2021. The life expectancy was at its peak in 2019, where it was roughly 80 years, but in 2020 the life expectancy decreased. For females, the average life expectancy increased from approximately 80.5 to 83 years. The sudden drop in life expectancy around the year 2020 is visible in female life expectancy as well. Even though females consistently have higher life expectancies than males do, the relative increase in life expectancy is lower for females than it is for males; under three years and almost six years, respectively.

A narrowing difference in average life expectancy between border- and non-border regions would indicate convergence. This goes two ways: either non-border regions are doing worse and are thus nearing the border regions' life expectancies, or border regions are catching up to non-border regions' life expectancies. The second way would be in line with what was argued in the theory section. Despite the average increase in life expectancy, border- and non-border regions' life expectancies appear to have increased quite linearly, meaning that there are no clear indications of convergence in life expectancy between border- and non-border regions since 1992. There are a few occasions in the female model in which the differences do narrow around 1995 and 2009. However, in order to determine convergence one should interpret the general trend, which does not suggest convergence in life expectancy between border- and non-border regions. During the whole period of interest, the border regions' average life expectancy is below that of the non-border regions and the pattern does not appear to be significantly different in 1988 to 1991 than it is from 1992 onwards.

Even though convergence is not necessarily found, the difference between the border- and non-border average in life expectancy is relatively small: it is quite stable around roughly 0.5 for males and around 0.3 for females. This is visible in the white bandwidth between the red and the blue line, which remains relatively static over time. Furthermore, the difference between average border- and non-border life expectancies does not increase, so there is no divergence either. Figure 7 and 8 provide more information of the actual difference between the average life expectancies of border- and non-border regions.

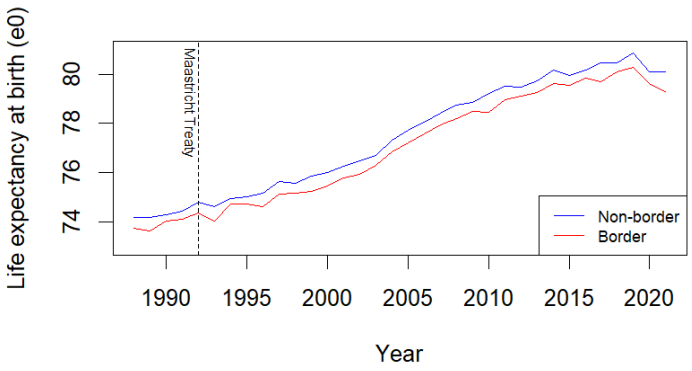

Figure 2. Average male border- and non-border life expectancy 1988-2021. Source: CBS (2022a; 2022b), own visualisation.

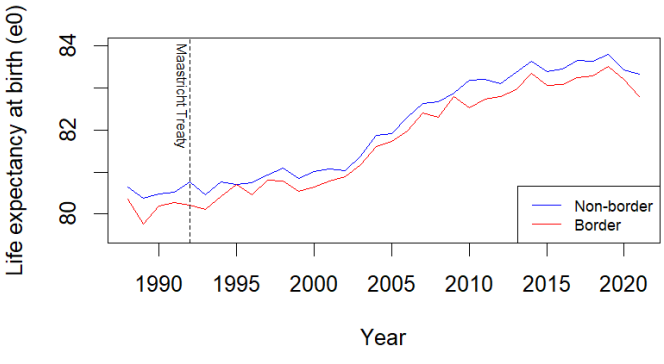

Figure 3. Average female border- and non-border life expectancy 1988-2021. Source: CBS (2022a; 2022b), own visualisation.

As discussed in the theory section, border regions are not an homogenous block. For instance, it could be the case that not all border regions are outperformed by the non-border regions or that convergence in life expectancy can be observed with singular border regions. The spatial patterns will be assessed in more detail in paragraph 4.2, but line graphs can already help to get a sense of the development of singular border regions' life expectancy compared to the non-border average. Figure 4 and 5 have the same axes as Figure 2 and 3. Hence, they indicate the trajectories of life expectancy, in which the Y-axis denotes the life expectancy in years and the X-axis the years in time. However, instead of the average border- and non-border life expectancy trajectories, the singular border regions' life expectancy trajectories are now plotted against the non-border average. Each coloured line represents a border region ($n = 15$) and the thick black line represents the non-border average. Similarly to the results on the previous two figures, the current section will look into the general trends of life expectancy, whether convergence is present and the width of the differences between border- and non-border regions.

In line with Figure 2 and 3, the overall pattern shows continuously increasing life expectancy trends for males and females between 1988 and 2021, in which 1988 to 1991 does not appear to differ from 1992 onwards. Even though the lines might appear a bit "spikier" than in Figure 2 and 3, all of the regions generally experienced improving life expectancy values. All of the regions also seem to follow a more or less linear trend, as there are no regions with a noticeably steeper slope.

Regarding convergence, it differs per border region whether its life expectancy trajectory resembles that of the non-border average. Furthermore, the slopes themselves hardly changed. In other words, if border regions tend to have a certain 'position' with respect to the non-border average, they are unlikely to have converged towards it. So, there are no clear signs of convergence in life expectancy between border- and non-border regions from 1992 onwards. At the same time, there is no indication of divergence either.

Hence, the difference between the singular border regions' life expectancies and the non-border average is relatively stable over time. That does not mean that the difference between every border region and the non-border average is the same, but rather that the difference does not change much. An interesting pattern emerges: in both the male- and female case, the vast majority of border regions ($n = 13$) indeed tend to have lower life expectancies than the non-border average at all points in time. The region "Oost-Groningen" (dark blue) particularly stands out, as it is structurally below the other border regions. On the other hand, the regions "Overig Zeeland" (grey) and "Zeeuws-Vlaanderen" (sea green) generally have higher life expectancies than the non-border average over the whole period. For some regions the difference to the non-border average life expectancy is quite narrow, for example in the case of "Noord-Overijssel" (yellow), where the difference is almost not visible. For others, the difference is quite large, particularly in the case of "Oost-Groningen" (dark blue). Therefore, a more nuanced image arises: border regions have different tendencies and one should be wary to draw conclusions about singular (non-) border regions based on their averages.

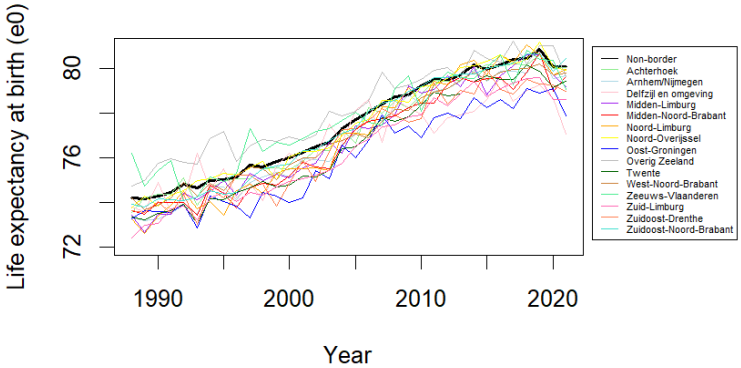

Figure 4. Male border regions' life expectancy compared to non-border average 1988-2021. Source: CBS (2022a; 2022b), own visualisation.

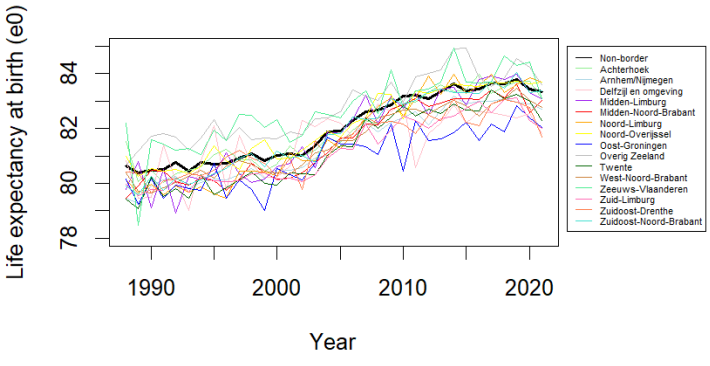

Figure 5. Female border regions' life expectancy compared to non-border average 1988-2021. Source: CBS (2022a; 2022b), own visualisation.

Figures 2, 3, 4 and 5 give a relevant overview of the development of life expectancy trajectories over time, but it is quite hard to read what the width of the gap in life expectancy between border- and non-border regions is, considering the wide interval of life expectancy values it corresponds to. Moreover, the distance on the Y-axis that represents two years in male $e0$ (Figure 2 and 4), equals one year in female $e0$ (Figure 3 and 5). Just interpreting the difference in trends by the line graphs can thus be tricky and yields the risk of premature conclusions. Therefore, Figures 6, 7, 8 and 9 present more information of the actual differences in life expectancy. Figure 6 and 7 are an addition to Figure 2 and 3, as they denote the differences in average life expectancy of border- and non-border regions. Figure 8 and 9 build on Figure 4 and 5, as they visualise the difference between border regions' life expectancies and the non-border average. The figures have the exact same values on their axes, so it is easier to compare the differences in average male- and female life expectancies between border- and non-border regions. The Y-axis denotes the difference in years between the border region(s) and the non-border average, the X-axis denotes the years in time. The dashed line denotes the Maastricht Treaty and the horizontal line at Y's 0 indicates complete convergence, in which there is no difference between border- and non-border regions' life expectancies. A positive value on the Y-axis means that the non-border regions' average $e0$ is higher than that of border regions; a negative value on the Y-axis means that the non-border regions' average $e0$ is lower than that of border regions. This is because their difference is calculated by subtracting the border region's value from the non-border average. From these figures, it cannot be determined whether life expectancy trajectories have increased, as solely their differences are projected. Therefore only the differences in life expectancy between border- and non-border regions and whether these differences have converged will be interpreted.

In general, there is no clear indication of convergence in Figure 6 and 7. The differences in average life expectancy fluctuate on a relatively stable basis, but overall the zero-line remains mostly untouched. The only exceptions are in Figure 7, in which there are two instances that are nearing the zero-line: 1995 and 2009, as noted about Figure 3. However, when examining the overall pattern, these two instances are of little importance. Furthermore, the general pattern does not appear to change after 1992, so it is unlikely that the European Integration has resulted in convergence in average life expectancy between Dutch border- and non-border regions.

In both figures, the differences do not exceed the zero-line into the negative values, which means that there has not been a case (on average) in which the border regions' life expectancy was higher than that of the non-border regions. Regarding the width of the differences, the difference appears to be narrower for women than it is for men. To elaborate; in the average male life expectancy (Figure 6), the differences in $e0$ fluctuate around 0.5 years, whereas they fluctuate around 0.2 years for females (Figure 7). At several points in time, the differences in male life expectancy are smaller than 0.5. These can be found for instance around 1989, 1994 and 2016. At the same time, the differences are greater than 0.5 in 2010 and 2017. The larger differences in female life expectancy can be found in the years 1989, 1992 and 2011.

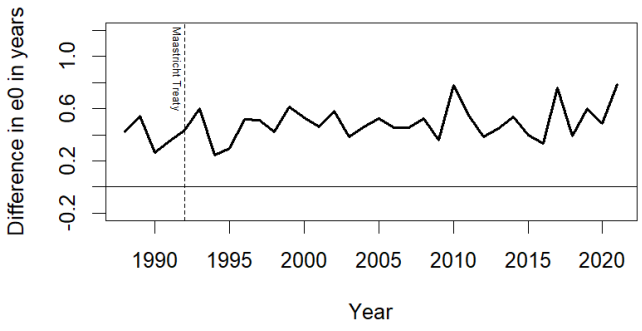

Figure 6. Difference in average male life expectancy between border and non-border regions 1988-2021. Source: CBS (2022a; 2022b), own visualisation.

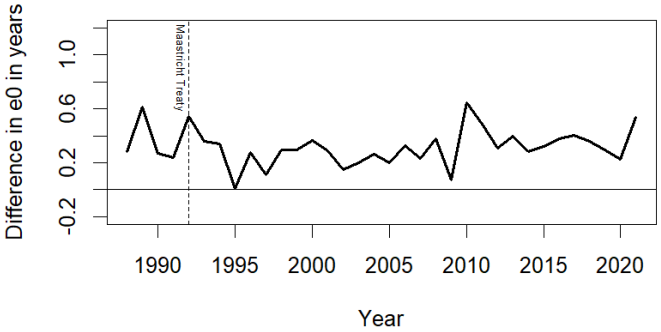

Figure 7. Difference in average female life expectancy between border- and non-border regions 1988-2021. Source: CBS (2022a; 2022b), own visualisation.

Then, Figure 8 and 9 present the differences between border regions' life expectancies and the non-border average. For the border regions, the same colours are used as in Figure 4 and 5.

Regarding the life expectancy trajectories between border regions and the non-border average, there is relatively little support for convergence. Again, "Noord-Overijssel" (yellow) is almost on the zero-line at every point in time. However, it was that way prior to 1992, so it did not necessarily converge towards the non-border average since the European Integration. Furthermore, despite the relatively stable patterns of the border regions, two regions stand out: "Overig Zeeland" (grey) and "Zeeuws-Vlaanderen" (sea green). In line with what we previously saw, these two regions have higher life expectancies than the non-border average (keep in mind that a negative value refers to the non-border average life expectancy being lower than that of the respective border region). At the same, these are the only two regions of which their slopes have slightly changed, not particularly in their favour. More specifically, Figure 8 indicates that "Overig Zeeland" (grey) and "Zeeuws-Vlaanderen" (sea green) are nearing the zero-line. However, this does not indicate a catch up of the respective regions, but rather a fall back towards the non-border average. This tendency is less prominent in the female case (Figure 9). Generally speaking, the pattern of 1988-1991 appears to be similar to that of 1992-2021, so there are no clear indications that the European Integration has facilitated accelerating convergence in life expectancy between border- and non-border regions.

Similarly to Figure 4 and 5, the differences in life expectancy between the respective border regions and the non-border average depend per region. "Oost-Groningen" (dark blue), as well as "Delfzijl en omgeving" (pink) tend to have higher positive values, meaning that they tend to lag behind the furthest to the non-border regions. Despite converging towards the zero-line, "Overig Zeeland" (grey) and "Zeeuws-Vlaanderen" (sea green) tend to have relatively large positive values, indicating higher life expectancies than the non-border average. In general, those regions have an $e0$ of about 1.5 above the non-border average, even reaching 2 years for males in 1995. The other regions are situated between "Noord-Overijssel" (yellow) and "Oost-Groningen" (dark blue).

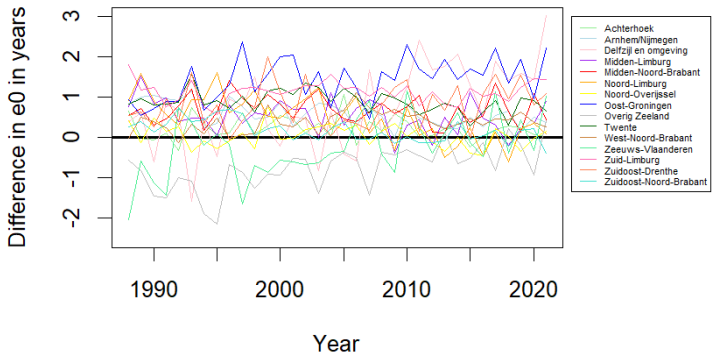

Figure 8. Difference in male life expectancy between border regions and non-border average 1988-2021. Source: CBS (2022a; 2022b), own visualisation.

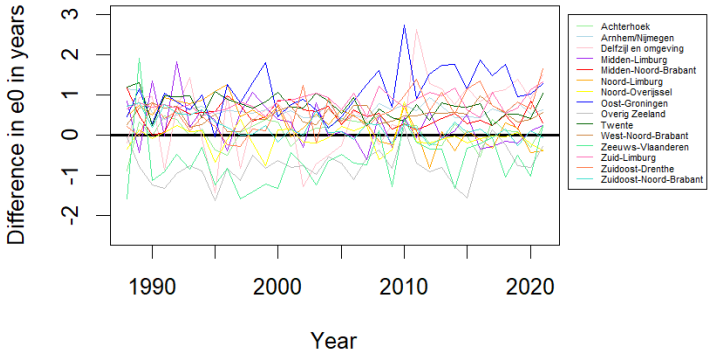

Figure 9. Difference in female life expectancy between border regions and non-border average 1988-2021. Source: CBS (2022a; 2022b), own visualisation.

4.2. Spatial patterns

The previous results presented patterns of average border regions' life expectancies (Figure 2, 3, 6 and 7), as well as their individual trends compared to the non-border average (Figure 4, 5, 8 and 9). Maps serve as an informative addition to this analysis, because those allow to visualize the regional spatial patterns. Consequently, as Figure 8 and 9 identified that the overall spatial patterns remain predominantly similar over time, four maps for each sex will be presented. This translates into maps for 11-year intervals: 1988, 1999, 2010 and 2021. All maps, i.e. Figure 10, 11, 12, 13, 14, 15, 16 and 17[1], have the same colour palette. The life expectancy data per respective year are grouped into quintiles, which are depicted in the legends. In between brackets, the ranges of corresponding life expectancies are denoted. The maps will now be discussed by year.

In 1988, for male life expectancy (Figure 10), almost the all border regions belong to the second quintile, with $e0$s ranging from 73.2 to 73.9 years. "Zuid-Limburg" is in the lowest category, with a life expectancy between 72.4 and 73.2 years. The South-Western border regions appear to be more advanced in 1988, in which "West-Noord-Brabant" belongs to the third quintile (73.9 – 74.7 years), "Overig Zeeland" is in the fourth quintile (74.7 – 75.5 years) and "Zeeuws-Vlaanderen even has the country's highest life expectancy (75.5 – 76.2 years). The spatial pattern is slightly different for females (Figure 11). "Zeeuws-Vlaanderen" does have the highest life expectancy there as well, but there are more border regions in the lowest category (79.4 – 80.0 years): "Twente", "Arnhem/Nijmegen", "Midden-Limburg", "Zuidoost-Noord-Brabant" and "Midden-Noord-Brabant". "Achterhoek" is doing better than it is on the male side, which is also the case for "Zuid-Limburg". Regarding the non-border regions, the majority is in the third category, respectively 73.9 - 74.7 years for males and 80.5 - 81.1 years for females. Quite remarkably, the life expectancy of "Groot-Amsterdam" is as least as low as most border regions.

In 1999 the general colour patterns change, in which relatively more regions are part of the fourth quintile compared to 1988. It does become apparent that "Oost-Groningen" lags behind all other regions, which was already visible from Figures 4, 5, 8 and 9. Meanwhile, the border regions "Overig Zeeland" and "Zeeuws-Vlaanderen" can be considered frontrunners, as their life expectancies are higher than in most of the country (i.e. 76.2 – 76.8 years for males; 81.4 – 82.1 years for females). For females, "Noord-Overijssel" also belongs to the highest life expectancy quintile (Figure 13). "Zuidoost-Drenthe" is in the lowest category for the males, whereas it is in the third category for females. The other way around, "Delfzijl en omgeving" is in the fourth category for males (75.6 – 76.2 years), but in the second category for females (79.6 – 80.2 years). The non-border regions are predominantly in the third and fourth quintiles, some are even in the highest one. The exception is "Groot-Amsterdam", which is in the second quintile for female life expectancy (79.6 – 80.2 years).

Then, in 2010 (Figure 14 and 15), "Oost-Groningen" is the only region in the lowest $e0$-category for both sexes (i.e. 76.9 – 77.6 years for males; 80.4 – 81.2 years for females). The male border regions tend to be doing worse than the female ones, at least in the case of: "Delfzijl en omgeving", "Zuidoost-Drenthe", "Twente", "Achterhoek", "Zuid-Limburg", "Midden-Noord-Brabant" and "Zeeuws-Vlaanderen". Compared to 1999 and 1988, it is striking that "Zeeuws-Vlaanderen" fell back compared to the other regions. This is in line with what was discussed about Figure 9, on the withdrawal of the South Western border regions. The non-border regions are predominantly in the fourth category, which falls between 79.1 and 79.8 years for males and between 82.8 and 83.6 years for females. Almost all regions improved, except for "Flevoland" for females, which fell back from the third category in 1999 (80.2 – 80.8 years) to the second in 2010 (81.2 – 82.0 years). Its life expectancy has still increased, but its speed lags behind relative to the others.

[1] One might notice that the IJsselmeer is not present on the maps (Figure 10 – 17), which is an inland bay situated between the provinces of Friesland, Noord Holland and Flevoland. The maps presented throughout this study depict Total Land Area (TLA), thus excluding lakes, rivers, transitional- and coastal waters (Eurostat, n.d.).

In 2021 (Figure 16 and 17), “Oost-Groningen” continues to lag behind (i.e. 77.1 – 78.0 years for males; 81.7 – 82.2 years for females). It is joined by “Delfzijl en omgeving” for both sexes, and “Zuidoost-Drenthe” and “Zuid-Limburg” for females as the worst performing regions regarding life expectancy. All of these regions are border regions. Particularly “Oost-Groningen” has lagged behind since 1999 for both sexes, so even though its life expectancy has increased, it does not appear to have occurred in a pace to be able to catch up with the non-border (and other border) regions. However, a region does not necessarily have to be a border region to lag behind. Take for example the non-border region “Noord-Friesland” for both sexes and “Zuidoost-Zuid-Holland” and “Zuidwest-Overijssel” for females, which are doing at least as bad as most of their bordering counterparts in 2021. The difference is that these regions fluctuate, and they are not structurally doing worse than the others. This is also the case for the border region “Zuid-Limburg”, which has a relatively low life expectancy compared to the other regions in 2021, but in 1999 and 2010 it was more or less similar to the other (border) regions.

Overall, the spatial patterns imply several tendencies: the North-Eastern border regions (e.g. “Oost Groningen” and “Delfzijl en omgeving”) tend to structurally lag behind the other border regions, whereas the South-Western “Zeeuws-Vlaanderen” and “Overig Zeeland” have remarkably high life expectancies, oftentimes even higher than the majority of the non-border regions. The remaining border regions tend to fluctuate a bit more, but on average, they tend to have lower life expectancies than most the non-border regions do. Regarding convergence, it appears that the majority of border regions have converged from the lowest quintiles to the higher quintiles over time, except for the border regions in the country’s North East, which keep lagging behind. However, keep in mind that this is a relative disadvantage: for males the lowest quintile increased from 72.4 - 73.2 years in 1988 (Figure 10) to 77.1 – 78.0 years in 2021 (Figure 16) and for females it increased from 79.4 – 80.0 years in 1988 (Figure 11) to 81.7 – 82.2 years in 2021 (Figure 17). This denotes the larger relative increase in life expectancy for males than for females once again.

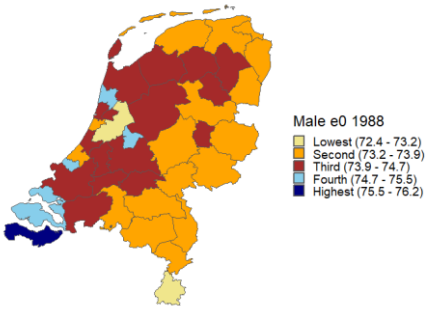

Figure 10. Regional male life expectancy 1988. Source: CBS (2022a; 2022b), Eurostat (2021), own visualisation.

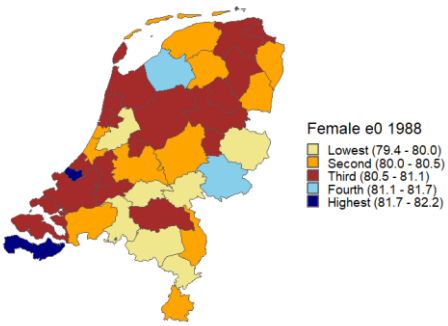

Figure 11. Regional female life expectancy 1988. Source: CBS (2022a; 2022b), Eurostat (2021), own visualisation.

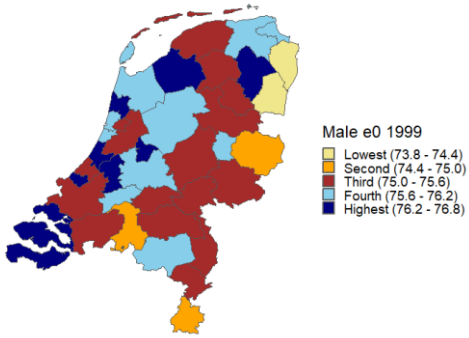

Figure 12. Regional male life expectancy 1999. Source: CBS (2022a; 2022b), Eurostat (2021), own visualisation.

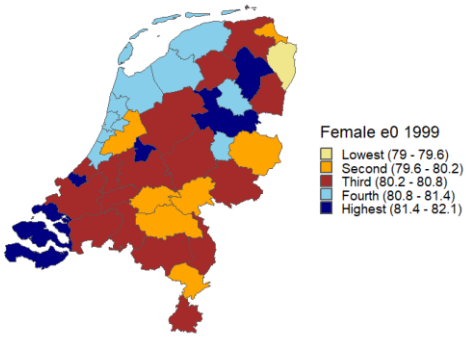

Figure 13. Regional female life expectancy 1999. Source: CBS (2022a; 2022b), Eurostat (2021), own visualisation.

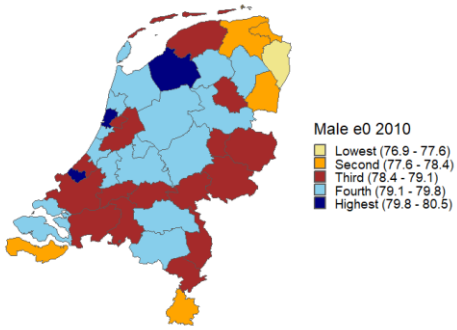

Figure 14. Regional male life expectancy 2010. Source: CBS (2022a; 2022b), Eurostat (2021), own visualisation.

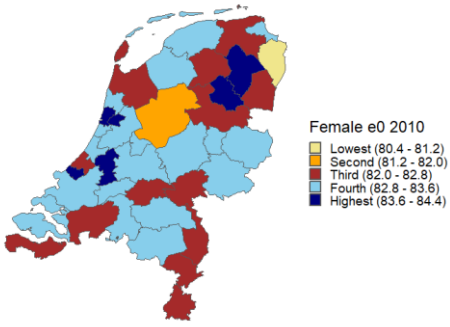

Figure 15. Regional female life expectancy 2010. Source: CBS (2022a; 2022b), Eurostat (2021), own visualisation.

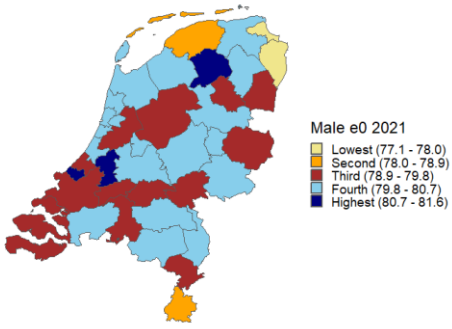

Figure 16. Regional male life expectancy 2021. Source: CBS (2022a; 2022b), Eurostat (2021), own visualisation.

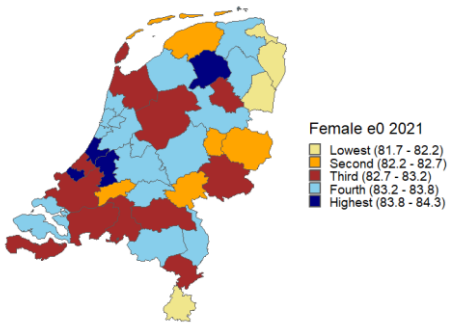

Figure 17. Regional female life expectancy 2021. Source: CBS (2022a; 2022b), Eurostat (2021), own visualisation.

4.3. The role of contextual factors

The panel regression's descriptive statistics have been discussed in paragraph 3.2. Before moving on, light will be shed on bivariate analyses and the adjustments those led to. Initially, variables on in- and out-migration were intended to be included. However, these are likely two sides of the same coin: someone who moves away arrives somewhere else, particularly in the case of internal migration. To get a better understanding of the extent that the migration variables are related, their correlation is calculated, which is extremely high ($r = 0.92$). Hence, it would benefit the analysis to remove one of the two as they tend to explain the same variance (Agresti, 2018). By doing a stepwise panel regression, both migration variables turn out to have a negligible effect on the fit of the model. Therefore – in line with the theory – the analysis will be performed with in-migration only. Furthermore, it can be argued that population growth is affected by in-migration. Their correlation is 0.34, which means that they have the same direction (higher in-migration results in greater population growth), but their relationship is relatively weak (Agresti, 2018). Consult Appendix II's Table 2 for the correlation-matrix.

The coefficients of a panel regression analysis indicate the change in the dependent variable – the difference in life expectancy between border and non-border regions – by changes in the independent variables (Brüderl & Ludwig, 2014). As addressed in paragraph 3.1, a fixed effects panel regression controls for time-invariant factors outside the model. Therefore, the coefficients are interpreted in the sense of "keeping the other time-varying variables in the model constant", as the variables outside the model are already at a constant level. Now, the results of the fixed effects panel analyses by sex will be presented.

4.3.1. Male panel regression

In model 1, the categorical variable for the time period is included, in which the pre-Maastricht Treaty period (1988-1991) serves as the reference group. The short-term effect is negative ($b = -0.002$; $SE = 0.09$; $p = 0.98$), suggesting that the difference in life expectancy between border- and non-border regions would widen immediately after the Maastricht Treaty of 1992. However, this coefficient is not statistically significant and its standard error is larger than its effect size, implying that there is a lot of uncertainty involved. The effect of the long-term period (1996-2021) is positive ($b = 0.11$; $SE = 0.07$; $p = 0.10$), but this effect is not statistically significant either. Hence, the standard error is relatively large and the confidence interval would contain 0, making it impossible to reject the hull hypothesis of no effect on the dependent variable. This large uncertainty is also visible in the measures of fit. The quality of the model can be assessed by R^2 and the F-statistic. R^2 represents the goodness of fit, and indicates the amount of variance in life expectancy that can be explained by the model (Agresti, 2018). In model 1, the R^2 is 0.01, which means that around 1% of the variance in differences in life expectancy between border- and non-border regions can be explained by the current model. Besides R^2, the F-statistic also investigates the quality of the model. Once the F-statistic is significant, one can reject the null hypothesis that all of the models' coefficients equal zero (Agresti, 2018). Model 1's F-statistic also gives a rather unfortunate conclusion: the null hypothesis that all models' coefficients equal zero cannot be rejected (F-statistic = 2.495; $p = 0.084$).

In model 2, the variable on the difference in GDP per capita is added. The coefficients of the time period do not change tremendously; they remain statistically insignificant and have relatively large standard errors. The coefficient for GDP per capita suggests that a narrowing difference in GDP per capita between border- and non-border regions is associated with a narrowing difference in life expectancy between border- and non-border regions ($b = 0.00005$; $SE<0.001$; $p<0.001$). Even though the effect appears to be small, keep in mind that it represents a narrowing of one unit, in this case €1,-. To make this finding more intuitive, a narrowing of €1,000,- in GDP per capita would result in a narrowing of over 18 days in life expectancy between border and non-border regions. The R^2 has increased to 0.054 and the F-statistic indicates a statistically significant improvement of the model by including the difference in GDP per capita as an independent variable (F-statistic = 9.370; $p<0.001$).

In model 3, the difference in employment per thousand between border- and non-border regions is added. This coefficient is statistically significant as well, suggesting that a catch up of the border regions with 1,000 people corresponds with a narrowing of the difference in life expectancy between border- and non-border regions ($b = 0.005$; $SE = 0.001$; $p = 0.002$). Moreover, would 10,000

more people get into employment in border regions, the difference in life expectancy already narrows with 18,3 days. The other coefficients change a little as well as a result of the inclusion of the employment-variable. For instance, the negative short-term effect increases, but remains statistically insignificant (b = -0.06; SE = 0.09; p = 0.49). The long-term effect – which used to be positive – turns negative and remains statistically insignificant (b = -0.13; SE = 0.09; p = 0.13). The effect of GDP per capita remains positive and significant, but decreases a little (b = 0.00003; SE<0.001; p = 0.002). Now, a catch up of €1,000 in GDP per capita in border regions would result in a narrowing in life expectancy between border- and non-border regions of 11 days. R^2 has increased relatively much, in which now 7,2% of the variance in differences between border- and non-border life expectancies are explained. Again, the F-statistic also denotes a statistically significant improvement of the model (F-statistic = 9.535; p<0.001).

In model 4, the difference in relative in-migration between border- and non-border regions is added to the model. Its coefficient implies that an 1‰ increase in border regions' in-migration would result in a narrowing difference of 0.003 (approximately one day) between border- and non-border regions' life expectancies. However, the coefficient is not statistically significant and its standard error is the same size as its effect size (b = 0.003; SE = 0.003; p = 0.33). The other variables – short-term effect, long-term effect, GDP per capita and employment – remain exactly the same, suggesting that in-migration does not provide a lot of additional explanatory power to the model. This is supported by model 4's R^2, which has increased from 0.072 in model 3 to 0.074 in model 4. However, adding this variable to the analysis can still be considered a minor contribution to the model, as the F-statistic is statistically significant (F-statistic = 7.817; p<0.001).

In model 5, the variable on the difference in population growth between border- and non-border regions is added to the analysis. Similarly to what happened after adding in-migration to model 4, the other coefficients of model 5 do not change due to the inclusion of the population growth measure. The effect of population growth itself appears to be negative, meaning that an 1‰ catch up of border regions would widen the difference in life expectancy between border- and non-border regions (b = -0.0005; SE = 0.01; p = 0.962). However, its standard error is again extremely large in comparison with the effect size, so it is no surprise that this effect is not statistically significant. Now, R^2 does not increase in comparison with the previous model (0.074). As there are statistically significant coefficients in the model (i.e. GDP per capita and employment), the F-statistic is statistically significant (F-statistic = 6.501; p<0.001), but one can question the extent to which this model is an improvement from the previous one.

Finally, in model 6, the difference in the share of people being aged 65 and over is added. This does not appear to have an impact on the short-term and long-term effect. The coefficient of GDP per capita experiences a minor increase in its p-value, hence it going from statistically significant at p<0.01 to p<0.05. The coefficient of employment increases in size and significance (b = 0.007; SE = 0.002; p<0.001). Now, when 10,000 more people are getting into employment in border regions, the life expectancies between border- and non-border regions will converge with 25.6 days. The effect-size decreases a little and its SE increases for in-migration compared to the previous model (b = 0.002; SE = 0.004; p = 0.54). The measure for population growth now turns positive and stronger (b = 0.002; SE = 0,01; p = 0.86), but the coefficient does not become statistically significant. The newly added variable, on the difference in people aged 65 and over, suggests that a narrowing difference of 1% between border and non-border regions in their amount of people aged 65-plus, would result in the narrowing of the difference in life expectancy between border and non-border regions by 0.052. Would the border- and non-border regions' share of elderly converge by, say 10%, this would narrow their differences in life expectancy by 190 days. However, the coefficient is not statistically significant, so one cannot make definite statements about the influence of this variable on narrowing differences in life expectancy between border- and non-border regions. The R^2 of the final model is 0,079, indicating a small increase in the variance that can be explained by the model in comparison to the previous model. The F-statistic is also significant, but not very large (F-statistic = 5.942; p<0.001). Hence, the final model could be argued to be the best fit for this specific fixed effects panel regression analysis. Table 4 gives an overview of the entire stepwise panel regression, with its six models.

Overall, the greatest contributions to narrowing differences in male life expectancy between border- and non-border regions thus appear to be the model 6's statistically significant variables for the difference in GDP per capita as well as the difference in employment. This is also visible in the relative improvement in R^2 when these variables are added to the model. It increased 0,044 from GDP per capita (model 2) and 0.018 from employment (model 3), whereas adding the other variables could increase R^2 with 0.005 at most (model 6).

Table 4. Male fixed effects panel regression.

	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
	b	SE	b	SE	b	SE	b	SE	b	SE	b	SE
Short-term (1992-1995)[a]	-0.002	0.09	-0.03	0.09	-0.06	0.09	-0.06	0.09	-0.06	0.09	-0.06	0.09
Long-term (1995-2021)	0.11	0.07	0.03	0.07	-0.13	0.09	-0.13	0.09	-0.13	0.09	-0.13	0.09
Δ GDP per capita			0.00005***	<0.001	0.00003**	<0.001	0.00003**	<0.001	0.00003**	<0.001	0.00003*	<0.001
Δ Employment					0.005**	0.001	0.005**	0.001	0.005**	0.001	0.007***	0.002
Δ In-migration (‰)							0.003	0.003	0.003	0.003	0.002	0.004
Δ Population growth (‰)									-0.0005	0.01	0.002	0.01
Δ Aged 65+ (%)											0.05	0.03
R^2	0.010		0.054		0.072		0.074		0.074		0.079	
F-statistic	2.495		9.370***		9.535***		7.817***		6.501***		5.942***	

*significant at p<0.05, ** significant at p<0.01, *** significant at p<0.001. [a] Reference group: pre-Maastricht Treaty (1988-1991).

4.3.2. Female panel regression

The same procedure is performed for females, in which the variables are included in the same order. In the first model, the short-term and long-term effects of the categorical variable for time period are included. The short-term effect on differences in the life expectancy between border- and non-border regions is not statistically significant (b = -0.04; SE = 0.08; p = 0.65). Furthermore, its standard error is twice the effect size, so there is quite some uncertainty involved. That is also the case for the long-term effect, which implies a widening effect on differences in life expectancy between border- and non-border regions as well (b = -0.04; SE = 0.06; p = 0.53). The model is not necessarily able to explain variance in the dependent variable, as the R^2 is below 0.001. In other words, less than 0.1% of the variance in the dependent variable can be explained by model 1. As both coefficients come back statistically insignificant, it is not too surprising that the F-statistic is not significant either (F-statistic = 0.196; p = 0.82). More specifically, its null hypothesis of all coefficients being equal to 0 cannot be rejected.

In model 2, the difference in GDP per capita between border- and non-border regions is added to the analysis. This results in the time-period effects to become slightly stronger negative, both in the short-term effect (b = -0.06; SE = 0.08; p = 0.48) and in the long-term effect (-0.11; SE = 0.06; p = 0.09). A catch up of border regions in GDP per capita (by €1,-) results in narrowing life expectancies between border and non-border regions (b = 0.00004; SE<0.001; p<0.001). An increase of €1,000,- in the border regions' GDP per capita would thus significantly lead to an narrowing of the life expectancy between Dutch border- and non-border regions with 14.6 days. The R^2 has increased to 0.037, meaning that 3.7% of the variance in the dependent variable can be explained by the independent variables in model 2. Hence, the F-statistic is statistically significant as well (F-statistic = 6.429; p<0.001).

Then, in model 3 the difference in the number of employed people in thousands between border- and non-border regions is added. Now, the short-term effect becomes increasingly negative (b = -0.08; SE = 0.08; p = 0.32), suggesting widening differences in the life expectancy between border- and non-border regions. The long-term effect even becomes statistically significant, implying that the later in time, the wider the difference in life expectancy between border- and non-border regions becomes (b = -0.22; SE = 0.08; p = 0.007). The p-value of GDP per capita slightly increases, but it still remains significant at p<0.01. A catch up of the border regions in employment by 10,000 people is statistically significantly associated with an a narrowing in life expectancy between border- and non-border regions of around 11 days (b = 0.003; SE = 0.001; p = 0.03). The R^2 increases again, from 0.037 in model 2 to 0.047 in model 3. Also the relatively large F-statistic suggests that adding employment to the model increases its quality (F-statistic = 6.095; p<0.001).

In model 4, relative in-migration is added. The coefficient suggest that a catch up of the border regions of in-migration by 1‰ is positively associated with narrowing life expectancy differences between border- and non-border regions (b = 0.001; SE = 0.003; p = 0.75). However, the coefficient is not statistically significant and its standard error is substantially high. Therefore, it remains uncertain whether the coefficient differs from 0, as the null hypothesis cannot be rejected. The coefficients of the other variables remain exactly the same, suggesting that in-migration does not add noteworthy explanatory power to the model. This is also visible in the R^2, which does not visibly increase from the previous model's value of 0.047. Considering that GDP per capita still has a statistically significant coefficient, the F-statistic is naturally statistically significant (F-statistic = 4.887; p<0.001), but the model does not appear to be a great improvement from model 3.

In model 5, the difference in relative population growth between border- and non-border regions is included. An increase in relative population growth in border regions by 1‰ is significantly associated with a narrowing difference in life expectancy between border- and non-border regions of around 11 days (b = 0.03; SE = 0.01; p = 0.001). Would this increase be 10‰, the narrowing in life expectancy would already be 110 days. The coefficients of the other variables also change slightly after adding the difference in population growth to the model. More specifically, all effect sizes decrease and the coefficient for the difference in border- and non-border regions regarding in-migration even changes direction (b = -0.003; SE = 0.003; p = 0.41). However, it remains statistically insignificant. From adding the variable on population growth, the R^2 increases to 0.068, which denotes that the current model is able to explain around 7% of the variance of the dependent variable. The F-statistic also indicates an improvement of model 5 compared to model 4 (F-statistic = 5.936; p<0.001).

Finally, the difference in share of people aged 65 and over between border- and non-border regions is added to model 6. When the difference in the share of elderly narrows – so the relative amount of people aged 65+ decreases in border regions – the difference in their life expectancy tends to narrow as well (b = 0.03; SE = 0.03; p = 0.23), but this coefficient is not statistically significant. On the other hand, in the case of the difference in GDP per capita (b = 0.00004; SE<0.001; p = 0.01), employment (b = 0.004; SE = 0.002; p = 0.04) and population growth (b = 0.03; SE = 0.01; p<0.001) the null hypothesis can be rejected. Narrowing differences in these variables thus all point to narrowing differences in female life expectancy between border- and non-border regions. Similarly to the previous models, the short-term effect (b = -0.02; SE = 0.08; p = 0.79), the long-term effect (b = -0.15; SE = 0.08; p = 0.07) and in-migration (b = -0.003; SE = 0.003; p = 0.35) are not statistically significant and their effect sizes have slightly decreased from the inclusion of the difference in the share of people aged 65 and over. The R^2 of the final model increased up to 0.071. Which, together with the F-statistic (F-statistic = 5.300; p<0.001) imply a better fit of model 6 than of the previous models. Altogether, the independent variables are able to account for little over 7% of the variance in differences in life expectancy between border- and non-border regions.

Overall, the results of the fixed effects panel regression on the difference in female life expectancy between border- and non-border regions are relatively similar to that of the male analysis. In both cases, a narrowing difference between border- and non-border regions in GDP per capita and employment is significantly associated with a narrowing difference in their life expectancies. Additionally, a narrowing difference in population growth between border- and non-border regions is significantly associated with narrowing differences in female life expectancy. In the female analysis, the relative increase of R^2 is substantial from adding the difference in GDP per capita between border- and non-border regions (roughly 0.037). Its increase is 0.010 from adding the difference in employment between border- and non-border regions and 0.021 from adding the difference in relative population growth between border- and non-border regions, while the other variables are able to increase R^2 with 0.003 at most (model 6). The sixth model of the male analysis is able to explain 7.9% of the variance in the difference in male life expectancy between border- and non-border regions; for the female model this is slightly lower, with a final R^2 of 0.071.

Table 5. Female fixed effects panel regression.

	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
	b	SE	b	SE	b	SE	b	SE	b	SE	b	SE
Short-term (1992-1995)[a]	-0.04	0.08	-0.06	0.08	-0.08	0.08	-0.08	0.08	-0.03	0.08	-0.02	0.08
Long-term (1995-2021)	-0.04	0.06	-0.11	0.06	-0.22**	0.08	-0.22**	0.08	-0.17*	0.08	-0.15	0.08
Δ GDP per capita			0.00004***	<0.001	0.00004**	<0.001	0.00004**	<0.001	0.00003**	<0.001	0.00004*	<0.001
Δ Employment					0.003*	0.001	0.003*	0.001	0.002	0.001	0.004*	0.002
Δ In-migration (‰)							0.001	0.003	-0.003	0.003	-0.003	0.003
Δ Population growth (‰)									0.03**	0.01	0.03***	0.01
Δ Aged 65+ (%)											0.03	0.03
R^2	<0.001		0.037		0.047		0.047		0.068		0.071	
F-statistic	0.196		6.429***		6.095***		4.887***		5.936***		5.300***	

*significant at p<0.05, ** significant at p<0.01, *** significant at p<0.001. [a] Reference group: pre-Maastricht Treaty (1988-1991).

5. DISCUSSION

5.1. Summary of the main results

The main focus of this study was to assess the role of European Integration on convergence in life expectancy trajectories between border- and non-border regions from 1992 onwards. The additional aim was to determine the role of contextual factors in the trends of border- and non-border life expectancy trajectories and to gain insight in the spatial patterns involved. In general, life expectancy trajectories increased, in both border- and non-border regions. However, there is no compelling evidence of convergence between these trajectories, as the (relatively small) difference between border- and non-border regions remains quite stable over time. Apart from a few spikes towards convergence in the female case, the general trends do not depict support for convergence. When comparing singular border regions to the non-border average, slightly more nuanced statements can be made. On one hand, the majority of the border regions have lower life expectancies than the non-border average, particularly "Oost-Groningen". On the other hand, two regions tend to have higher life expectancies than the non-border average: "Overig Zeeland" and "Zeeuws-Vlaanderen". The life expectancy of the region "Noord-Overijssel" is almost identical to the non-border average. Despite a fall down of the pioneering border regions "Overig Zeeland" and "Zeeuws-Vlaanderen" resulting in convergence in a way, the trends of the regions remain at a relatively constant distance to the non-border average. Hence, there is no clear difference between the period 1988-1991 and 1992-2021. Consequently, there is no strong support for the first hypothesis that life expectancy trajectories have converged between border- and non-border regions since 1992's European Integration.

Regarding the second hypothesis, apart from some fluctuations, there are more border regions in the same, higher quintiles as non-border regions in 1999, 2010 and 2021 than there were in 1988, which suggests convergence. This conclusion differs from that of analysis 1, likely because analysis 2 compares all regions instead of border regions to the non-border average. The border regions in the country's North-East (i.e. "Oost-Groningen" and "Delfzijl en omgeving") tend to lag behind, whereas the regions "Overig Zeeland" and "Zeeuws-Vlaanderen" are predominantly ahead of most non-border regions. Therefore, the second hypothesis is partly supported. Indeed, there appear to be converging tendencies between border- and non-border regions, but it is not necessarily the case that convergence is stronger is the Southern and/or Western regions than it is in Eastern/North-Eastern regions due to their relatively stable position compared to the non-border regions.

Finally, the fixed effects panel regression indicated that a catch up in border regions' GDP per capita and employment is associated with slightly narrowing differences in life expectancy between border- and non-border regions. In addition, the female analysis revealed that a catch up in relative population growth in border regions is linked with narrowing differences in border- and non-border life expectancy trajectories. As the effects of the time period proved statistically insignificant, there is no evidence that differences in life expectancy between border- and non-border regions narrow as time progresses after the Maastricht Treaty. Therefore, the third hypothesis is partly supported, as GDP per capita, employment and population growth were expected to have a narrowing effect on the difference in life expectancy trajectories between border- and non-border regions. The hypothesised positive effect of in-migration and the negative effect of the population share aged 65-plus are thus not supported.

5.2. Embeddedness within the theory

As discussed in the theory section, the border regions are assumed to be the laggards that are catching up to the non-border vanguards at different speeds. To allow a catch up in health of the lagging regions, relevant new health tools, innovations and the ability to implement those need to be present, which relate to the economy, political- and social structure at hand (Vallin & Meslé, 2004; Meslé & Vallin, 2017). The lack of strong evidence for convergence since the European Integration would mean, in line with Vallin and Meslé (2004), that the border regions' situation has not improved to the extent that their health could fully catch up to that of the non-border regions.

Regarding analysis 2's spatial patterns, no regions appear to have converged more than others. The results do indicate that the South-Western border regions generally have high life expectancies, whereas the North-Eastern border regions tend to lag behind. This can be explained by Krugman's (1991) core-periphery model. Hence, the further away from the country's core – which is initially

located in the West – the less desirable it is for firms to settle due to increasing transportation costs. It was hypothesised that all border regions would become fruitful places for development following the European Integration, because the country borders have gotten less of a barrier, thus lowering transportation costs. The relative lack of convergence in life expectancy suggests that the attractiveness of (most) border regions has not increased to the extent that regional (economic) activity significantly flourished. Moreover, analysis 3 indicated that a catch up of border regions in GDP per capita, employment and population growth (for women) would result in converging life expectancy with the non-border regions, so the lack of convergence following the European Integration implies that border regions' circumstances have not improved enough to allow narrowing differences in life expectancy trajectories with the non-border regions.

Several sources underscore the lack of improvement in border regions. For instance, cross-border transport routes are not prepared for increased use, not even in the most developed European border regions (Medeiros, 2019). Even if transport routes were to improve, it would not necessarily mean that (cross-border) citizens would use them. In the case of the transnational medical travel (Ormond & Lunt, 2019, p.4180), Dutch citizens prefer to stay longer on waiting lists to receive care in the Netherlands than to travel abroad for healthcare, even when they live in a border region (Brouwer, van Excel, Herman, & Stoop, 2003). This might be related to differences in language, unfamiliar goods and services and accessibility issues in the current study's cross-border regions (Spierings & van der Velde, 2013), despite the assumption that Belgium and Germany are culturally similar to the Netherlands. If the traditionally peripheral border regions have not had the means to transition into core-like regions, they did not have substantial opportunities to innovate and to develop (Moore, 1994), which would explain the lack of convergence in life expectancy between border- and non-border regions.

5.3. Interpretation of results

Considering that Janssen et al. (2016) find evidence for regional convergence in the Netherlands over 1988-2009, it might appear unexpected that the current study does not. However, the current study compares border- and non-border regions rather than all regions, which could explain this outcome. Even though the European Integration might have prevented divergence in life expectancy trajectories, the results indicate that it did not facilitate convergence either. On an international level, Hrzic et al. (2021) come to the same conclusion, implying that the lack of convergence following the European Integration is not bound to the Dutch context. Thus, the question remains: why has the European Integration been unable to facilitate a catch up in life expectancy? Two explanations will be elaborated below.

The first explanation has to do with the type of collaboration between the European Member States. At the time of the Maastricht Treaty, economic collaboration was believed to result in the harmonisation of living standards, which is referred to as the endogeneity thesis (Wagner, 2014). Therefore, the agreements of the Maastricht Treaty capture policies on free trade, a common market and a monetary union with the same currency. The funds of the European Union thus aim to invest in the economy of its Member States (Vukašina, Kersan-Škabić, & Orlić, 2022). However, there is no such thing as a political union or a social union (Glawe & Wagner, 2021), so health- and social policies remain the responsibility of individual Member States (Vollaard, van de Bovenkamp, & Vrangbæk, 2013). The lack of EU-collaboration on healthcare has been found to be related with large variations between and within Member States in the quality and safety of healthcare (Suñol, Garel, & Jacquerye, 2009). The Dutch social security system stems from the year 1901, which consists of employee insurance and national insurance (Berghman, Nagelkerke, Boos, Doeschot, & Vonk, 2003). As discussed in the theory section, periphery regions tend to be faced with unemployment, impoverishment (Szul, 2006; Nijkamp, 1993), lacking infrastructure and little supply of jobs and services (Bernard, 2019; Nijkamp, 1993). It is thus not too surprising that unemployment- and disability benefits (i.e. WW and WIA) are above average in the (North-)Eastern regions, as well as in Limburg in the South-East, whereas the population of Western regions rarely receive social benefits more often than the national average does (CBS, 2012; CBS, 2015). Regarding Dutch healthcare, the

relative costs have increased continuously over time as well (Jeurissen & Maarse, 2021). As the responsibility for health- and social policies remained at Member States, the European Integration has not made more means available to specifically invest in (regional) healthcare nor social security. This might explain why the border regions have not fully caught up to the non-border regions, as the social determinants of health entail factors such as socioeconomic status, educational level, employment, living conditions, social support networks and access to healthcare (Artiga & Hinton, 2018). Put differently, perhaps the European Integration could not completely counteract the (socially) disadvantaged position of border regions.

The second explanation has to do with the main actors that benefitted from the economic developments of the European Integration. Namely, the European Integration is argued to have predominantly been a collaboration of the capital cities (CBI & EDR, 2021). In light of the current study, this would mean that Amsterdam, Antwerp and Berlin are actively involved with each other. In line with Krugman's (1991) notion on transportation costs, the larger cities would be attractive locations to settle for firms - particularly after the introduction of the four principles of free movement – thus further enhancing their already favourable positions. Antwerp is situated relatively close to the Southern Dutch border regions, which are exactly the regions that showed the least signs of lagging behind to the non-border regions in the current study. Berlin on the other hand, is located in the outer West of Germany, so there is likely less incentive to settle in the Dutch-German cross-border regions. Hence, if there is little economic activity at the other side of the border too, both sides of the border are likely to remain relatively disadvantaged. This relative disadvantage might become a downward spiral: as discussed earlier, relatively well-off people tend to move away to regions with more opportunities (Gächter & Theurl, 2011). The people who move, generally have higher socioeconomic statuses, which is associated with personal characteristics that improve health, such as personality, food practices and cognitive ability (Mackenbach, 2010). Consequently, Rogers (1962) argues in his theory 'diffusion of innovations', that health inequalities are the result of quicker improvements in people with higher socioeconomic statuses, because those people tend to adopt new (health) behaviours and new interventions earlier on. Referring back to Vallin and Meslé (2004), health behaviours indeed are among the determinants of health improvements. Considering that the better-off people move away from border regions, the worse-off tend to stay behind, which would explain why the population decline in border regions has not fully recovered yet (Gouveia, Correia, & Martins, 2020). This mechanism of selective out-migration could cause spatial concentrations of worse health in border regions and better health in non-border regions. Namely, the drift hypothesis argues that direct selection – the moving decisions of ill- and non-ill people – would lead to spatial concentrations of people in similar health conditions (Verheij, 1996). This does not mean that Dutch border regions have not benefitted from the European Integration, but it has likely benefitted the non-border regions to a greater extent, allowing them to be in a structurally more advanced position.

The results also contain a few findings that do not directly relate to the research questions, but would benefit an interpretation: the drop in life expectancy from 2020 onwards and the larger relative increase in life expectancy for men compared to women. Regarding the first point, the COVID-19 pandemic likely played a role. More specifically, the high numbers of deaths in 2020 have not been observed since the Second World War in many countries, including the Netherlands (Aburto et al., 2021). Consequently, mortality rates indicate that more Dutch people passed away than there would have without the pandemic, particularly in the older ages (Stoeldraijer, 2020). Regarding the second point, the decreasing sex difference in life expectancy is likely related to changing patterns in smoking-induced mortality (Janssen & Spriensma, 2012; Janssen, 2020). Traditionally, males took up smoking earlier and smoked more than females did. However, females started smoking when the male smoking prevalence went down already, resulting in a decrease of smoking-induced mortality in males and an increase of smoking-induced mortality in females (Janssen, 2020).

5.4. Limitations

The current study would have benefitted from a greater availability of regional, longitudinal data, particularly in the panel regression analyses. The scarcity of contextual data led to relatively little explanatory variables, in which the covariates on GDP per capita, employment, in-migration and population growth are not by sex. In the current study's panel regression, the influence of for instance culture is taken into account, but unobserved time-varying phenomena outside the model are not. As the analyses' final R^2 has been relatively low - particularly in the case of women - there are likely other time-varying factors involved with narrowing differences in life-expectancy trajectories in border- and non-border regions. This could be factors related with narrowing health differences including improving healthcare (Mackenbach et al., 2019) or rising educational levels (Hahn & Truman, 2015; Bilas et al., 2014). Future research should aim to include such factors.

Unavoidably so, the current study also has several methodological limitations. First, the border regions' life expectancies are mainly compared to the non-border average. Otherwise, convergence of 15 border regions would have to be determined between 25 non-border regions, which adds more depth, but would also exceed the scope of the current study. The maps of analysis 2 do give insight in the relationship between border- and non-border regions, but the current study does not allow to compare life expectancy trajectories between border- and non-border regions individually. Including all non-border regions in each analysis could provide more insight on convergence between singular border- and non-border regions (rather than to the non-border average), as well as on "Groot Amsterdam's" unexpected position being among the lowest life expectancy quintiles.

Second, the current study analyses convergence in life expectancy trajectories by comparing border- and non-border regions within the same country; the Netherlands. However, convergence could also be viewed from a different perspective by taking the neighbouring border regions of Belgium and/or Germany as a reference. Such an approach could yield different results regarding convergence in life expectancy trajectories. It could also contribute to a better understanding of population flows and the mechanisms associated with life expectancy trajectories in border regions. This is something to consider for future research.

Third, apart from life expectancy at birth, no other health measures are assessed. Despite being a commonly used measure for health (OECD, 2021), life expectancy does not capture the amount of life spent in bad health. Healthy life expectancies could thus be a useful addition, which can differ per region as well (Bělohradský & Glocker, 2019). Out of interest, the current study's analysis 1 and 2 were also performed for the remaining life expectancies at age 65, in which no evidence for convergence is found either. The analysis is presented in Appendix III.

5.5. Future research and policy recommendations

The previous paragraphs already touched upon several directions that might be fruitful for future research. First, the current study is conducted in a rather homogenous setting, as the differences in life expectancy trajectories between border- and non-border regions are generally not large. Therefore, it would be interesting to study a similar research question in a cross-border setting or in a country with wider differences in life expectancy, for instance France, Germany or the United Kingdom (Thomson et al., 2017).

Second, the current study predominantly assessed the non-border average for comparisons with border regions, rather than singular non-border regions. The current methodology using line graphs would not be suitable to study all 40 regions, but one could consider to assess beta and sigma convergence like Janssen et al. (2016) did, to compare border- and non-border regions' life expectancy convergence.

Third, it would be very beneficial to include more contextual factors in the study. When one intends to conduct a similar study in another context, more data outlets might be available. Moreover, more data might be obtained from other sources, which is out of scope for the current study. Considering that this is the first study on the difference in life expectancy trajectories between border- and non-border regions, it is hard to determine to what extent the results would be generalizable to other contexts. It could be relevant for similar-size North-European countries, but this is something that future research should indicate.

This ties in with the first policy recommendation of the current study, which is about data availability. The aforementioned lack of regional, longitudinal data sources would also pose an issue for future research, so it is necessary to increase the availability of such data. For instance, the number of hospital beds is only available as a national measure, while it is composed of all hospitals in the Netherlands (CBS, 2022e). It would be beneficial to academia and local governments to make the regional data from hospitals readily available. Therefore, it is recommended to publish data from regional actors (i.e. hospitals, municipalities, schools and institutions) prior to merging them into one dataset, under the condition that anonymity is always ensured. CBS could include the regional data in its "Nederland regionaal" (regional Netherlands) folder. This would allow regional actors - such as local governments - to map their citizens' overall situation and to act accordingly.

The next policy recommendation is related to responding accurately to local people's needs. The results of this study identified that decreasing differences in GDP per capita, employment and population growth (for women) between border- and non-border regions are linked with narrowing differences in life expectancy. Helping the border regions catch up on those factors will thus contribute to the reduction of health inequalities within the Netherlands. Particularly "Oost-Groningen" and "Delfzijl en omgeving" could use a hand. This can be achieved by increasing economic activity and the attractiveness of these regions, to boost economic growth and to prevent further out-migration. However, the North-Eastern regions have little trust in the national government, fuelled by the gas extraction's induced earthquakes (Visser & Haisma, 2021; Valk, de Jong, & Nanninga, 2023). Considering that local governments and civil services tend to be trusted more than national governments (OECD, 2022), a good way to start would be to invest in place-based regional development policies, with targeted training programs for the local labour market (Allain-Dupré, Michalun, & Upton, 2022). Furthermore, it is worthwhile to strengthen the cross-border ties with Germany, as their cooperation used to fall behind (Brand et al., 2009). Considering that healthcare remained the responsibility of Member States, stronger cooperation with Germany could increase the regions' attractiveness, improve the availability of local (health) services and provide job-opportunities at the other side of the border.

5.6. Conclusion

Despite its (methodological) limitations, the current study provides numerous contributions to the academic field. First, there were no suitable mid-year population counts available, so those were computed manually, as well as the regional life expectancies by sex. A test calculation of national male life expectancy in 2021 yielded a value of 79.73, which is very similar to CBS's (2022d) value of 79.68. This implies that the current study's regional life expectancies would be close to reality too.

Second, the current study adopted the core-periphery model (Krugman, 1991) and the convergence-divergence framework (Vallin & Meslé, 2004) on a regional level over time. Normally, the core-periphery model has a rather static approach, whereas the convergence-divergence framework is in essence internationally oriented. The results of the current study indicate that these theories lend themselves for analyses at other levels as well.

Third, this is not the first study to assess regional life expectancy trajectories over time (e.g. Gächter & Theurl, 2011; Janssen et al., 2016), but it is the first study to my knowledge to investigate life expectancy trajectories between border- and non-border regions. Therefore, the current study gives great insights into the trends of border- and non-border life expectancies, the width of their differences and the spatial patterns involved in the context of the European Integration.

Fourth, most scholars who investigate health inequalities do not include the drivers of convergence (Hrzric et al., 2020), which is particularly lacking on the already hardly studied regional level. Despite being forced by the scarcity of data to have relatively little explanatory variables, the current study found a small but statistically significant narrowing effect of a catch up in border regions' GDP per capita, employment and population growth (for women) on differences in life expectancy. The current study can thus be considered a first step in understanding (determinants of) converging life expectancy trajectories between border- and non-border regions following the European Integration.

In sum, the current study investigated the differences in life expectancy trajectories between Dutch border- and non-border regions over time, to assess the influence of the European Integration on convergence. On average, the results provide no compelling evidence of convergence from 1992 onwards, as the life expectancy trajectories of all regions increased relatively linearly. There are regional variations in the width of the difference in life expectancy, but those remain more or less stable over time and are typically not very large. The maps indicate that – in general - there are more border regions in the same, higher quintiles as non-border regions in 1999, 2010 and 2021 than there were in 1988, suggesting convergence since 1992. Regarding the spatial patterns, the border regions furthest behind (North-East) and furthest ahead (South-West) were already in these positions prior to the Maastricht Treaty, so it is hard to determine whether the extent of convergence is related to their location relative to the country's core. The analysis of the contextual factors revealed that greater GDP per capita, employment and relative population growth (for women) in border regions can (slightly) narrow the difference in life expectancy between border- and non-border regions. Directions for future research point to conducting a similar study in a less homogenous (cross-border) context, include all non-border regions individually and take more contextual factors into account. Policy recommendations emphasise improved data availability and regional initiatives to specifically invest in the regions needing it the most. These are steps in the right direction to achieve the aforementioned European- and local policy makers' goals of reducing health inequalities among European citizens, enhancing overall public health.

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APPENDIX I

To verify which exact Dutch COROP-regions are classified border regions, Germany Statistik Kompakt (2018) was consulted for the Dutch regions bordering Germany and CBS (2017) for the regions bordering Belgium. See Table 1 for the overview. Figure 1 visualizes the 40 COROP-regions and their corresponding codes.

Figure 1. The 40 Dutch NUTS-3 (i.e. COROP) regions. Source: Eurostat, 2020, p.100. [2]

[2] Similarly to explained in footnote 1, the IJsselmeer is not visible on the map due to TLA.

Table 1. Overview of the Dutch border COROP-regions and their corresponding codes.

Non-bordering COROP-regions	*Code*	*Bordering COROP-regions (BE = Belgium, DE = Germany)*	*Code*
Agglomeratie Haarlem	NL324	Oost-Groningen (DE)	NL111
Agglomeratie Leiden en Bollenstreek	NL337	Delfzijl en omgeving (DE)	NL112
Agglomeratie 's-Gravenhage	NL332	Zuidoost-Drenthe (DE)	NL132
Alkmaar en omgeving	NL328	Noord-Overijssel (DE)	NL211
Delft en Westland	NL333	Twente (DE)	NL213
Flevoland	NL230	Achterhoek (DE)	NL225
Groot-Amsterdam	NL329	Arnhem/Nijmegen (DE)	NL226
Groot-Rijnmond	NL33C	Noord-Limburg (DE)	NL421
Het Gooi en Vechtstreek	NL327	Midden-Limburg*	NL422
IJmond	NL323	Zuid-Limburg*	NL423
Kop van Noord-Holland	NL321	Zeeuws-Vlaanderen (BE)	NL341
Noord-Drenthe	NL131	Overig Zeeland (BE)	NL342
Noord-Friesland	NL124	West-Noord-Brabant (BE)	NL411
Noordoost-Noord-Brabant	NL413	Midden-Noord-Brabant (BE)	NL412
Oost-Zuid-Holland	NL33B	Zuidoost-Noord-Brabant (BE)	NL414
Overig Groningen	NL113		
Utrecht	NL310		
Veluwe	NL221		
Zaanstreek	NL325		
Zuidoost-Friesland	NL126		
Zuidoost-Zuid-Holland	NL33A		
Zuidwest-Drenthe	NL133		
Zuidwest-Friesland	NL125		
Zuidwest-Gelderland	NL224		
Zuidwest-Overijssel	NL212	* Borders with Germany and Belgium.	

APPENDIX II

This Appendix presents an additional fixed effects panel regression to the one discussed in paragraph 4.3. In this panel regression, only the border regions are included, while the dependent variable is life expectancy at birth. Contrary to the main analysis, the differences between border- and non-border regions are thus not investigated. The aim of this analysis is to assess the role of contextual factors on border regions' life expectancies in general. The descriptives of this analysis's variables are already included in paragraph 3.2's Table 3 in the box 'Border'. Hence, the bivariate relationships will be discussed in the next section.

II.I. Bivariate relationships

Table 1 presents the correlations between in-migration, out-migration and population growth in the border regions only. These correlations are thus part of Appendix II.I and II.II's fixed effects panel regression on the effect of multiple characteristics on border regions' life expectancy. Similarly to the bivariate relationships discussed in the main text (paragraph 4.3), the association between in-migration and out-migration is extremely strong (r = 0.950).

Table 1. Bivariate relationships border-regions-only.

	In-migration	Out-migration	Population growth
In-migration	1	0.950	0.039
Out-migration	0.950	1	-0.215
Population growth	0.039	-0.215	1

Table 2 presents the corresponding values of paragraph 4.3 in a correlation matrix, which resulted in the removal of out-migration from the analyses.

Table 2. Bivariate relationships border- and non-border regions.

	In-migration	Out-migration	Population growth
In-migration	1	0.917	0.335
Out-migration	0.917	1	-0.022
Population growth	0.335	-0.022	1

II.II. Border regions only male fixed effects panel regression

The variables of the male analysis are – similarly to the one discussed in the main text – added stepwise. This means that an independent variable is added in every model, in the same order as they were added in the main text. For simplicity, only model 6 will be interpreted; all other results are visible in Table 3.

Border regions' life expectancies appear to have increased in the period 1992-1995 (b = 0.17; SE = 0.13; p = 0.19) compared to 1988-1991. However, this effect is not statistically significant, so one should be careful in drawing conclusions. The later in time (1996-2021), the higher the border regions' life expectancies become (b = 0.57; SE = 0.14; p<0.001), while keeping all other time-varying variables constant. Compared to the short-term effect, male life expectancy increases over half a year. Furthermore, an increase in GDP per capita is significantly associated with increasing life expectancy in border regions (b = 0.0001; SE <0.001; p<0.001). More specifically, an increase of €1,000,- in GDP results in a prolonging of life with around 37 days. Employment also has a statistically significant positive effect on male life expectancy in border regions (b = 0.012; SE = 0.003; p<0.001). Once 10,000 more people are in employment, life expectancy generally increases with 44 days. Quite counterintuitively, the arrival of more migrants is associated with decreasing life expectancy in border regions (b = -0.012; SE = 0.005; p = 0.01). Every 1‰ increase in in-migration results in a decrease of a little over 4 days in life expectancy. Another unexpected finding is the statistically significant negative association between population growth and life expectancy in border regions (b = -0.09; SE = 0.014; p<0.001). When keeping the other time-varying variables constant, life expectancy tends to decrease when the population size increases. Lastly, again a surprising finding, a

higher share of elderly is related with increasing male life expectancy in border regions (b = 0.29; SE = 0.02; p<0.001). Every percent increase in the share of people aged 65 and over increases the border region life expectancy with roughly 106 days. This is a considerably large effect.

The model fit is extraordinarily high, in which over 91% of the variance in the male life expectancy in border regions can be explained by the model (R^2 = 0.914). The F-statistic also denotes a good fit of the final model (F-statistic = 741.837; p<0.001). In the main text, the R^2 did not exceed 8%, so this is a major difference. However, keep in mind that the dependent variables of the analyses are not comparable: the main text's analysis is on the difference in life expectancy between border- and non-border regions, whereas the current analysis is on the life expectancy in border regions. Life expectancy has the tendency to increase rather linearly, so the variance in life expectancy might be more straightforward to estimate than the difference in life expectancy between border- and non-border regions.

Table 3. Male fixed effects panel regression border regions only.

	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
	b	SE	b	SE	b	SE	b	SE	b	SE	b	SE
Short-term effect (1992-1995)	0.58	0.31	-0.21	0.15	-0.21	0.15	-0.21	0.15	-0.08	0.14	0.17	0.13
Long-term effect (1996-2021)	3.95***	0.23	-0.03	0.15	-0.05	0.15	-0.07	0.15	-0.02	0.15	0.57***	0.14
GDP per capita			0.0003***	<0.001	0.0003***	<0.001	0.0003***	<0.001	0.0002***	<0.001	0.0001***	<0.001
Employment in thousands					-0.004	0.003	-0.004	0.003	0.0005	0.003	0.012***	0.003
Relative in-migration (‰)							-0.003	0.005	0.012*	0.005	-0.012*	0.005
Relative population growth (‰)									-0.106	0.015	-0.09***	0.014
Aged 65+ (%)											0.29***	0.02
R2	0.473		0.876		0.877		0.877		0.887		0.914	
F-statistic	221.57***		1158.58***		871.246***		696.231***		641.183***		741.837***	

II.III. Border regions only female fixed effects panel regression

The same analysis as in II.I has also been done on border regions' female life expectancy. The results are presented below in Table 4. Similarly to the previous section, only the final model (with the best model fit) will be discussed.

Now, both time effects are negative, but they are not statistically significant (short-term: b = -0.13; SE = 0.10; p = 0.20; long-term: b = -0.07; SE = 0.11; p = 0.49). Hence, no definite statements can be made on the effect of the time period at hand on female life expectancy in border regions. In the female case, GDP per capita is also positively associated with life expectancy (b = 0.0001; SE<0.001; p<0.001). An increase of €1,000,- in GDP per capita would lead to an increase in life expectancy of around 37 days. Slightly weaker than in the male analysis, but an increasing number of people in employment is also significantly associated with increasing life expectancies in border regions (b = 0.007; SE = 0.002; p = 0.001). In this analysis, we also find the rather unexpected coefficient of in-migration, in which a greater number of arriving migrants would decrease the border regions' life expectancy (b = -0.009 ; SE = 0.004; p = 0.02). This is also the case for population growth, in which a 1‰ increase in the population size is associated with a decrease in life expectancy of around 15 days (b = -0.04; SE = 0.01; p<0.001). Quite surprising, the share of elderly is positively linked with life expectancy again, which means that a larger share of people aged 65 and over tends to increase the border regions' life expectancy by over 62 days (b = 0.17; SE = 0.02; p<0.001). The measures R^2 and the F-statistic suggest a good model. More specifically, over 82% of the variance in the female life expectancy in border regions can be explained (R^2 = 0.824). This is lower compared to the male model, but still it can be considered a very high value (Agresti, 2018). The F-statistic is less than half it was in the male model, but the female model can still be considered a good fit (F-statistic = 325.507, p<0.001), in which the null hypothesis of all coefficients being zero can be rejected.

Table 4. Female fixed effects panel regression border regions only.

	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
	b	SE	b	SE	b	SE	b	SE	b	SE	b	SE
Shortterm effect (1992-1995)	0.21	0.19	-0.24*	0.11	-0.24*	0.11	-0.24*	0.11	-0.18	0.11	-0.13	0.10
Long-term effect (1996-2021)	1.98***	0.14	-0.26*	0.11	-0.27*	0.11	-0.29**	0.11	-0.27*	0.11	-0.07	0.11
GDP per capita			0.0001***	<0.001	0.0001***	<0.001	0.0001***	<0.001	0.0001***	<0.001	0.0001***	<0.001
Employment in thousands					-0.001	0.002	-0.001	0.002	0.0005	0.002	0.007**	0.002
Relative in-migration (‰)							-0.004	0.003	0.002	0.004	-0.009*	0.004
Relative population growth (‰)									-0.05	0.01	-0.04***	0.01
Aged 65+ (%)											0.17***	0.02
R2	0.391		0.794		0.795		0.795		0.802		0.824	
F-statistic	158.194***		633.434***		474.719***		380.567***		329.209***		325.507***	

APPENDIX III

In addition to the investigation of life expectancy at birth, analysis 1 and 2 are performed for the remaining life expectancy at age 65, to assess whether the development in life expectancy trajectories between border- and non-border regions is similar in the older ages. These remaining life expectancies originate from the manually computed lifetable as discussed in paragraph 3.3, based on data from CBS (2022a; 2022b). Instead of the first row – life expectancy at birth – the life expectancy of age group 65-70 is now the main focus.

II.I. Average life expectancy trends e65

The average border- and non-border trajectories of remaining life expectancy at age 65 (Figure 1 and 2) appear to be relatively similar to those of life expectancy at birth. At all times, the border average e65 is lower than that of non-border regions and there is no clear evidence of convergence between the two from 1992 onwards. The differences between border-and non-border regions appear to be a bit smaller than they are in the trajectories of life expectancy at birth, particularly in the female case, but overall the results are quite comparable.

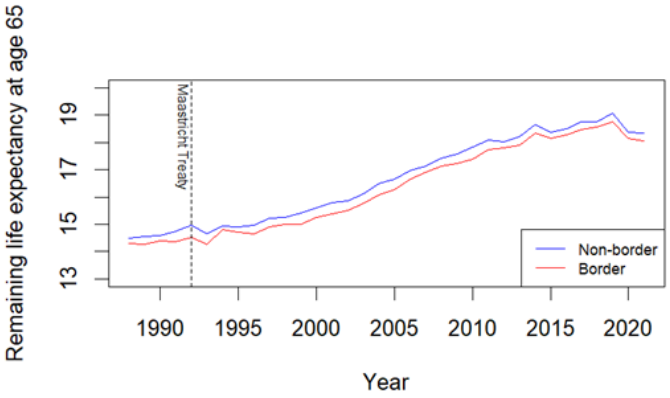

Figure 1. Average male border- and non-border e65 1988-2021. Source: CBS (2022a;2022b), own visualisation.

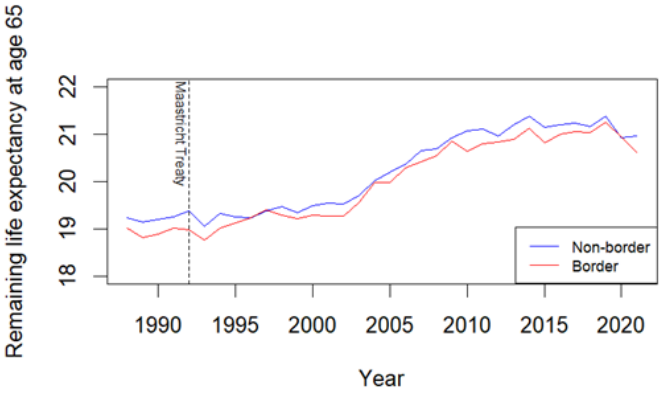

Figure 2. Average female border- and non-border e65 1988-2021. Source: CBS (2022a; 2022b), own visualisation.

II.II. Border regions' life expectancy trends e65

Figure 3 and 4 present the singular border regions' e65 compared to the non-border average. Apart from a few fluctuations, the relative advantage of "Overig Zeeland" (grey) and "Zeeuws Vlaanderen" (sea green) we saw in the main text are also applicable to the remaining life expectancy at age 65. "Oost-Groningen" (dark blue) is among the lowest remaining life expectancies again, but it is less pronounced than in the *e*0-case. Regarding convergence, the slopes of all regions tend to progress rather linearly, so based on these graphs there is no compelling evidence for convergence in remaining life expectancy at age 65 between border- and non-border regions from 1992 onwards.

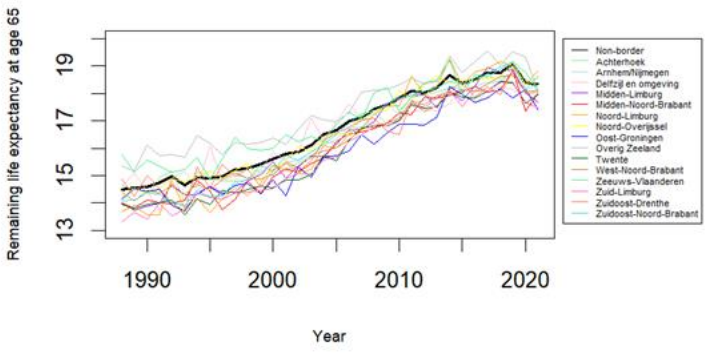

Figure 3. Male border regions' e65 compared to non-border average 1988-2021. Source: CBS (2022a; 2022b), own visualisation.

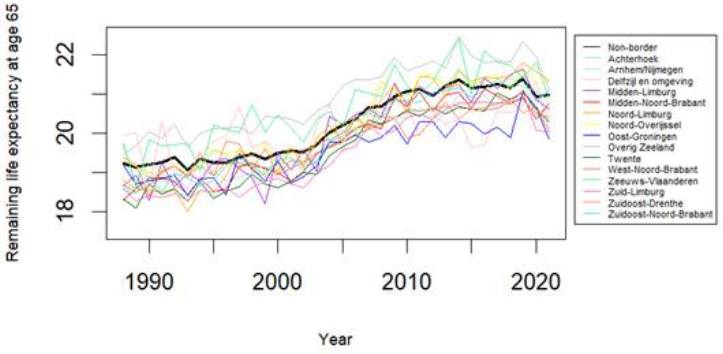

Figure 4. Female border regions' e65 compared to non-border average 1988-2021. Source: CBS (2022a; 2022b), own visualisation.

II.III. Differences average life expectancy e65

Figure 5 and 6 present the difference in years between the average border- and non-border remaining life expectancies at age 65. The overall width of the difference tends to be narrower in the female case than it is in the male case, even with a few occasions that gravitate towards convergence. Furthermore, the difference between border- and non-border regions appear to be narrower in the older ages than they were for life expectancy at birth. Despite these relatively slim differences, the general trends of both sexes do not necessarily indicate a converging influence of the European Integration on remaining life expectancy between border- and non-border regions.

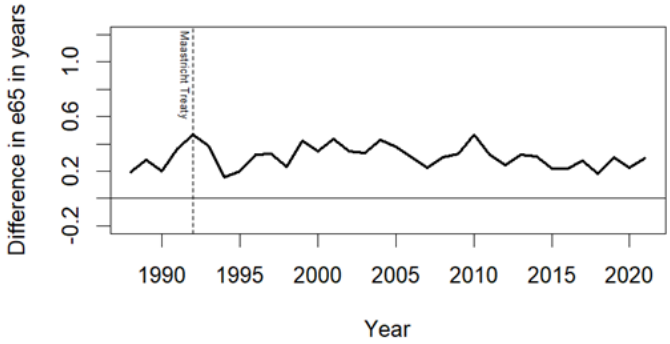

Figure 5. Difference in average male e65 between border and non-border regions 1988-2021. Source: CBS (2022a; 2022b), own visualisation.

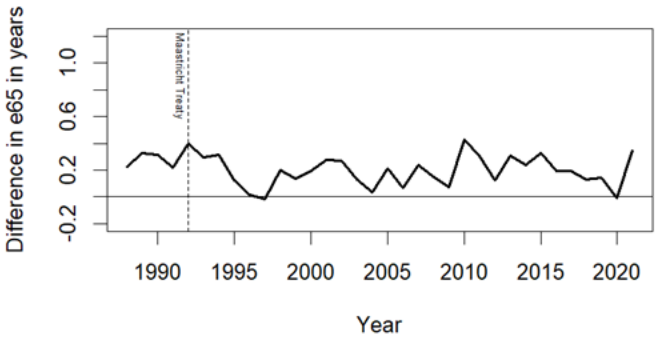

Figure 6. Difference in average female e65 between border and non-border regions 1988-2021. Source: CBS (2022a; 2022b), own visualisation.

II.IV. Border regions' life expectancy differences e65

The lack of convergence is clearly visible in Figure 7 and 8, which present the differences of each border region's e65 compared to the non-border average. The pattern we saw in the main text with "Overig Zeeland" (grey) and "Zeeuws-Vlaanderen" (sea green) generally having higher life expectancies than the non-border average, whereas "Oost-Groningen" (dark blue) tends to lag behind can be seen here as well. However, compared to the life expectancy at birth, the differences between the regions tend to be slightly smaller. More specifically, the difference between the best- and worst performing regions does not exceed two years in the remaining life expectancy at age 65, whereas it nears four years in several occasions for life expectancy at birth. Hence, the relatively stable life expectancy differences do not indicate a tendency towards convergence from the European Integration.

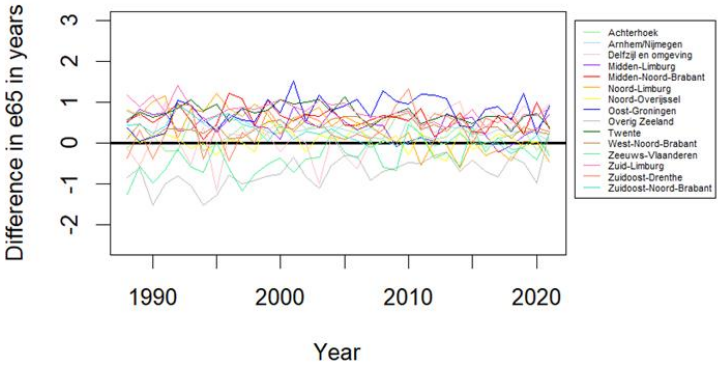

Figure 7. Difference in male e65 between border regions and non-border average 1988-2021. Source: CBS (2022a; 2022b), own visualisation.

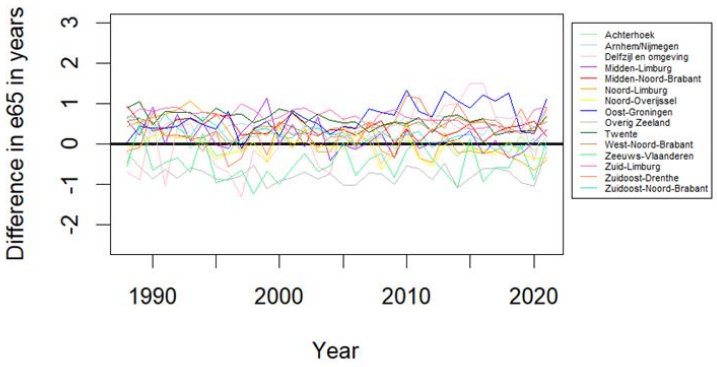

Figure 8. Difference in female e65 between border regions and non-border average 1988-2021. Source: CBS (2022a; 2022b), own visualisation.

II.V. Spatial patterns in life expectancy e65

Overall, the next page's Figure 9 to 16[3] depict slightly different spatial patterns than the life expectancy at birth did. For instance, in the years after the Maastricht Treaty (i.e. 1999, 2010 and 2021), there are not necessarily more (border) regions in highest life expectancy quintiles like there were for $e0$, implying that there is less convergence in life expectancy. Furthermore, "Groot Amsterdam" is never in the lowest quintile for e65, whereas it stood out in the main text, particularly in the early years. Similarly to $e0$, the North-Eastern regions of the Netherlands tend to lag behind at all points in time, whereas the South-Eastern regions are among the highest life expectancy quintiles (except for 2021). The Southern "Zuid-Limburg" tends to be doing a bit worse than it does in the visualisations for life expectancy at birth, but the differences are not huge.

[3] Similarly to explained in footnote 1, the IJsselmeer is not visible on the maps due to TLA.

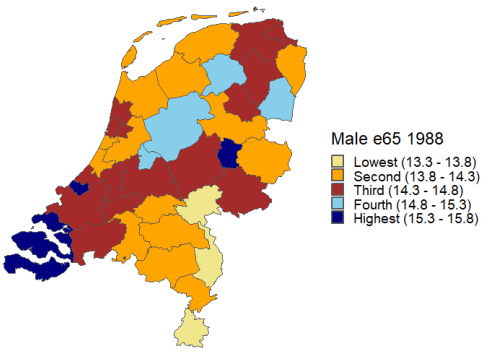

Figure 9. Regional male e65 1988. Source: CBS (2022a; 2022b), Eurostat (2021), own visualisation.

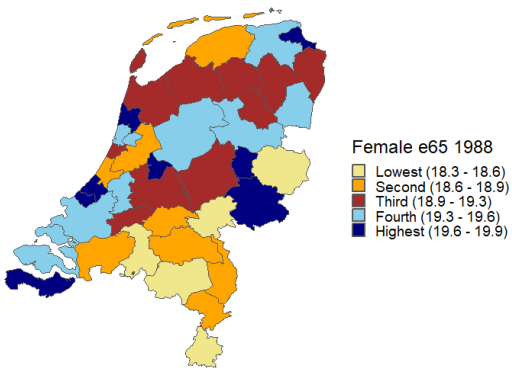

Figure 10. Regional female e65 1988. Source: CBS (2022a; 2022b), Eurostat (2021), own visualisation.

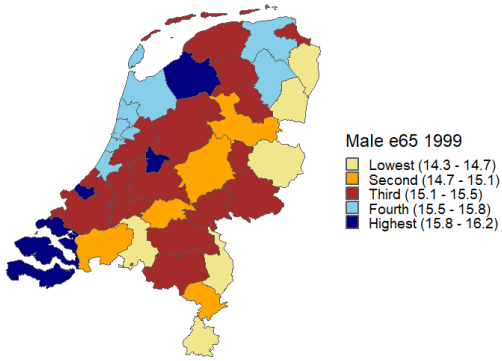

Figure 11. Regional male e65 1999. Source: CBS (2022a; 2022b), Eurostat (2021), own visualisation.

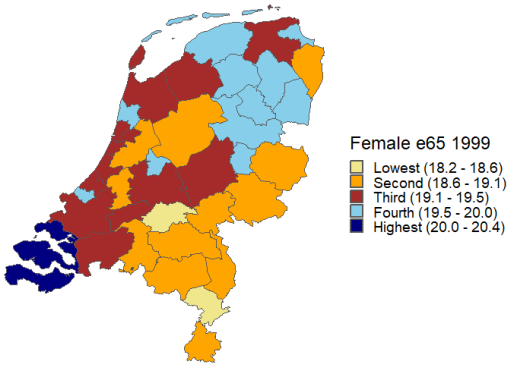

Figure 12. Regional female e65 1999. Source: CBS (2022a; 2022b), Eurostat (2021), own visualisation.

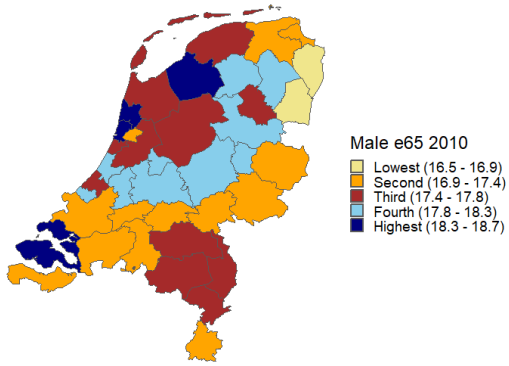

Figure 13. Regional male e65 2010. Source: CBS (2022a; 2022b), Eurostat (2021), own visualisation.

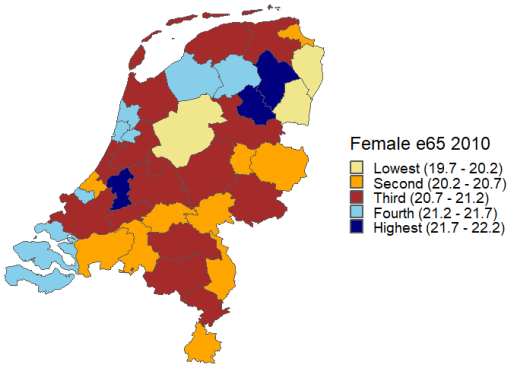

Figure 14. Regional female e65 2010. Source: CBS (2022a; 2022b), Eurostat (2021), own visualisation.

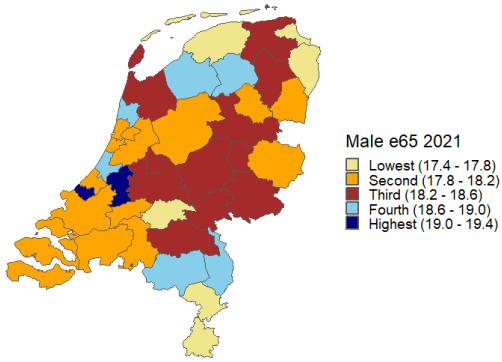

Figure 15. Regional male e65 2021. Source: CBS (2022a; 2022b), Eurostat (2021), own visualisation.

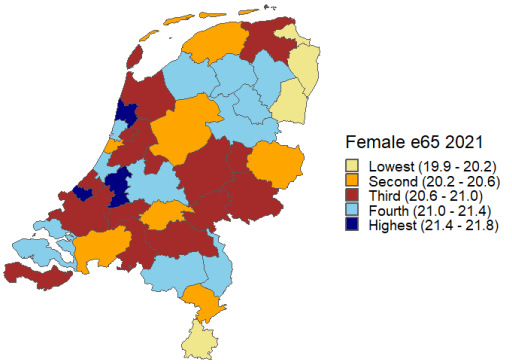

Figure 16. Regional female e65 2021. Source: CBS (2022a; 2022b), Eurostat (2021), own visualisation.