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THE APPLICATION OF THE KAPLAN-MEIER METHOD IN THE SURVIVAL ANALYSIS OF MARRIAGES IN SERBIA

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Abstract

Considering the changes in social norms and economic factors, the survival of marriages in Serbia can justifiably be classified as a current and significant research question. This study investigated the survival of marriages in Serbia during the period between 2011 and 2022. The sample included data from the Statistical Office of the Republic of Serbia, encompassing over 400,000 marriages and 24,240 divorces. The authors, aiming to estimate the probability of marital duration, employed the Kaplan-Meier curve in this work. The results indicated the presence of relative stability in marriages during the initial few years, with a gradual increase in the probability of divorce over time.

Key words: survival analysis, Kaplan-Meier curve, marriages, divorces, Serbia.

ПРИМЕНА КАПЛАН-МАЈЕР МЕТОДЕ У АНАЛИЗИ СТАБИЛНОСТИ БРАКОВА У СРБИЈИ

Апстракт

Имајући у виду промене у друштвеним нормама и економским факторима, преживљавање бракова у Србији се може, са правом, сврстати у актуелно и важно истраживачко питање. У раду је спроведено истраживање преживљавања бракова у Србији у периоду од 2011. до 2022. године. Узорком су обухваћени подаци Републичког завода за статистику Србије, који се односе на преко 400.000 склопљених бракова и 24.240 разведених бракова. Аутори су, вођени циљем да процене вероватноћу трајања бракова, у раду користили Каплан-Мајер криву. Резултати спроведеног истраживања указали су на присуство релативне стабилности бракова током првих неколико година, уз постепено повећање вероватноће за развод како време пролази.

Кључне речи: анализа преживљавања, Каплан-Мајер крива, бракови, разводи, Србија.

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INTRODUCTION

The dissolution of marriage is a phenomenon deeply rooted in the cultural and economic aspects of society and, as such, draws significant attention from scholars (Avellar & Smock, 2005). Following World War II, marriage rates in European countries rose substantially, which was associated with the return of stability and recovery after wartime devastation. During the 1950s and 1960s, marriage was the dominant form of union, and most couples chose to wed, leading to a relatively high marriage rate. However, in the early 1970s, divorce rates began to increase, driven by changes in social norms, the liberalisation of divorce laws, and the rise in women's emancipation, which allowed for greater economic independence.

From the 1980s onward, marriage rates gradually declined, while divorce rates continued to rise in most European countries as partners became less economically and socially dependent on one another. In the 1990s, many countries further liberalised divorce laws, facilitating separation processes, resulting in peak divorce rates in many European countries. Entering the 21st century, marriages became less common, while cohabitation and other forms of shared living became increasingly accepted.

Since the 2000s, although divorce rates remained high, the marriage rate continued to decline, partly due to a delay in marriage and a greater preference for living without formalising the union. The COVID-19 pandemic (2020) also affected these rates – many couples postponed weddings, while relationship challenges increased, leading to fluctuations in divorce rates.

By 2024, the marriage rate in Europe remained relatively low compared to the mid-20th century, while divorce rates stabilised in many countries. At the same time, there was considerable diversity across European nations; Scandinavian countries, for instance, continued to record high divorce rates, whereas rates in Southern and Eastern European countries were somewhat lower due to cultural and religious factors. These changes reflect a long-term transition toward altered family patterns, marked by rising individualism and changing attitudes toward traditional marriage institutions.

In postwar Serbia, starting in 1945, the marriage rate was relatively high as part of a broader trend of post-World War II recovery when people sought stability and family formation. During the 1950s and 1960s, marriage was a dominant social norm, and marriage rates were high, with low divorce rates due to conservative social norms and limited legal options for divorce. In the early 1970s, economic growth, modernisation, urbanisation, and the liberalisation of laws led to a gradual increase in divorce rates, though they remained lower than in Western European countries.

Throughout the 1980s, marriage rates in Serbia remained stable, but divorce rates began to rise due to increased economic independence for women and changing social attitudes toward marriage. With the start of the 1990s and the breakup of Yugoslavia, Serbia experienced socio-economic crises, armed conflicts, and sanctions, leading to a drop in marriage rates, while divorce rates

continued to rise due to stress from uncertainty and economic difficulties. In the 2000s, marriage rates slowly recovered but remained lower than before the 1990s, while divorce rates reached their peak, reflecting modernisation trends and a greater acceptance of divorce as an option.

In the second decade of the 21st century, the marriage rate stabilised, but couples often chose to marry later, reducing the overall rates. Meanwhile, divorce rates remained relatively high, with an increasing number of couples preferring cohabitation without formal marriage, following European trends. The COVID-19 pandemic (2020) led to a temporary decline in the number of weddings due to restrictions on gatherings, while divorce rates remained stable, though there was an increase in household stress.

By 2024, Serbia recorded a decline in marriage rates compared to the post-World War II period, while divorce rates stabilised but were higher than in the 1970s. The rise in individualism, economic challenges, and later marriages contributed to the reduction in marriage numbers, while divorce became an increasingly acceptable solution for marital conflicts.

The specificity of Serbia compared to other European countries is evident in the following two charts. Regarding marriage rates (Figure 1), it is noticeable that this rate is significantly higher in Serbia compared to other European countries, although a long-term decline and alignment with other countries can be observed. The curve for Serbia is at the top of the chart, clearly showing that, at the beginning of the observed decade, the marriage rate was twice as high as the European Union average.]

When it comes to divorce rate trends (Figure 2), the situation is different. Serbia falls below the European Union average, but does not significantly deviate, and aligns with some countries, such as Italy and Croatia.

Due to the specifics in the trends of marriage and divorce rates, there arose a need to explain these phenomena through the lens of available data. For this analysis, the database of marriages and divorces in Serbia for the period between 2011 and 2022, collected by the Statistical Office of the Republic of Serbia, was used. The complete database encompasses over 400,000 marriages and 108,000 divorces (including those from marriages contracted before 2011). For the purposes of this study, data on over 400,000 marriages contracted between 2011 and 2022, and 24,240 divorces related to marriages exclusively contracted within this period (not before it) were utilised. The aim of the study is to estimate the probability of marriage duration (survival) for marriages contracted in the observed period, through the application of survival analysis, specifically the Kaplan-Meier curve.

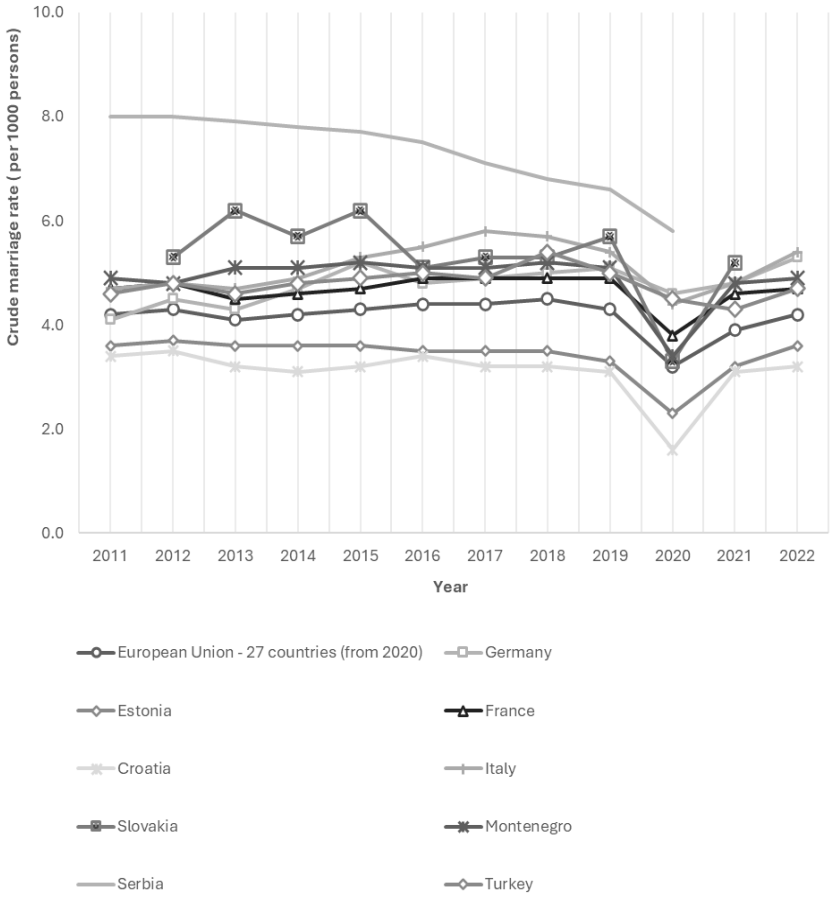

Figure 1. 'Crude' marriage rate (per 1,000 people) by selected countries, from 2011 to 2022

Source: Authors, based on data retrieved from https://ec.europa.eu/eurostat/databrowser

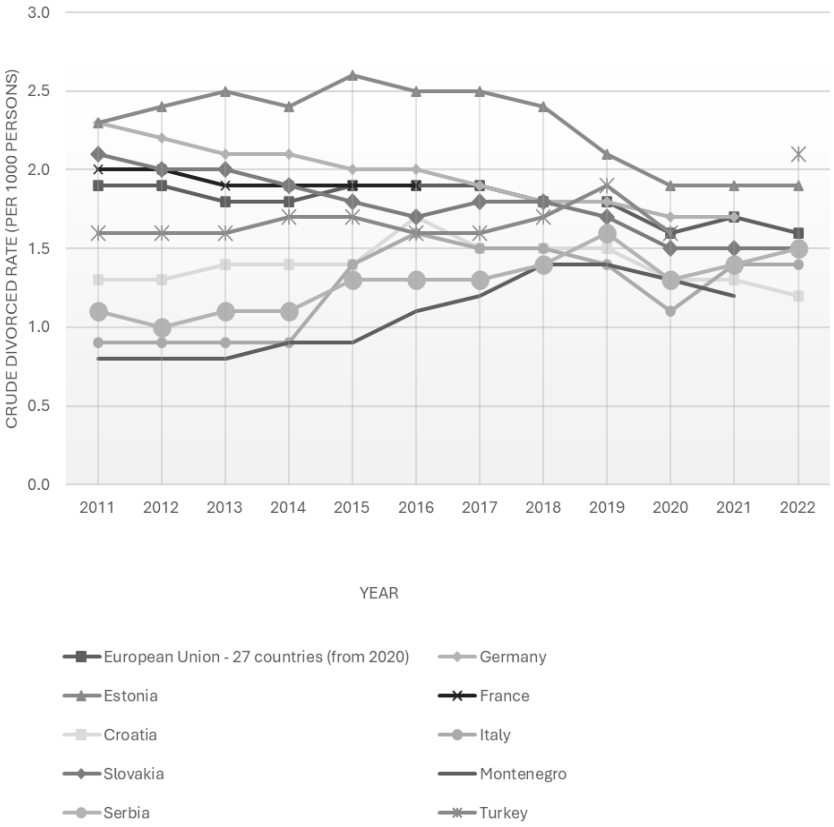

Figure 2. 'Crude' divorce rate (per 1,000 people) by selected countries, from 2011 to 2022

Source: Authors, based on data retrieved from https://ec.europa.eu/eurostat/databrowser

LITERATURE REVIEW

Life satisfaction stems from reflecting on one's life as a whole or through significant aspects such as marriage, family, work, friends, and so on (Šnele et al., 2020). In academic literature, the topic of divorce is explored from various angles, depending on the researcher's field of study. Common approaches include sociological, psychological, economic, legal, and social perspectives. Each approach aims to provide a deeper understanding of divorce and its consequences, both for individuals and for society.

Undoubtedly, one of the most significant contributions to the study of marriage in recent years is the collection of studies "Divorce in Europe: New Insights on Trends, Causes, and Consequences of Relationship Dis-

solutions" (Mortelmans, 2020). This book contains studies from across Europe and Israel, offering a comprehensive overview of family dynamics from a European perspective. The book includes both macro and micro-level studies, addressing the causes and consequences of separation. The macro perspective shows that divorce trends are evolving at different rates across Europe, beginning at different times. This is not limited to just the north-south axis, with Scandinavia leading and Southern Europe characterised by more stable marriages. The author notes that even Eastern Europe does not show a uniform pattern of divorce rates, despite the end of the communist era that hit them simultaneously.

Mortelmans also emphasises that while we still use the term 'divorce,' it no longer exclusively denotes the separation of married spouses. Instead, it has become a generic term for all separation processes, regardless of gender composition or legal ties, which will significantly impact changes in the scientific approach to this phenomenon.

In recent years, studies focusing on divorce factors have utilised various data sources, including longitudinal studies, national surveys, and social networks, and applied a wide range of statistical methods to examine the causes of divorce, from personal characteristics to sociocultural changes. Research findings in these studies indicate a complex interaction of personal, cultural, social, and economic factors affecting marital stability. Changes in social norms, such as increased gender equality and the deinstitutionalisation of marriage, are also linked to a higher risk of divorce, especially during phases when society experiences normative changes (Wagner, 2020). Wagner also argues that the increase in divorce rates is better explained by cultural changes than socioeconomic changes. The author analysed divorce factors using regression analysis on about 10,000 marriages.

Luhmann et al. (2014) point out that changes in personal circumstances, such as job loss, relocation, or health issues, can lead to personality changes that affect marital stability. Couples facing significant life changes are more prone to divorce, especially when such events are associated with stress and uncertainty. Couples who successfully adjust their behavior to changes have a better chance of staying together.

On the other hand, economic factors and intergenerational transmission of behavioral patterns also contribute to increasing divorce rates (Kaplan et al., 2020). The authors concluded that a larger family size does not necessarily reduce the risk of divorce, especially in pronatalist societies. Couples with more children may feel greater pressure and burden, leading to tensions within the marriage. Although social expectations suggest that larger families are more stable, the results show that this is not always the case. Financial burdens associated with many children also increase the likelihood of divorce.

As for research methodology, survival analysis is often used to study divorce and marriage in general. Scientific papers using this method to study divorce often highlight the significant impact of socioeconomic, health, and emotional factors on marital stability and on the survival of individuals after significant life events such as divorce or illness. These studies cover sample sizes ranging from several hundred to over ten thousand participants, analysing factors that affect marriage, divorce, and related health outcomes.

Numerous studies explore divorce analysis through the Kaplan-Meier curve from a health perspective, such as Landfeldt et al. (2018), Zhou et al. (2020), Zhou et al. (2016), Metayer et al. (1996), and Xie et al. (2018).

Ahmad et al. (2015) collected secondary data from the Islamic religious department in Selangor, Malaysia. The dataset consisted of 531 cases reported by couples who filed for divorce in 2012. Comparing Cox and parametric models, the authors highlighted significant regional differences in risk factors, with economic insecurity being a key driver of the divorce rate. The study focused on Cox regression, and the Kaplan-Meier curve was used only in the introductory part for descriptive purposes without detailed analysis.

Sanizah et al. (2014) applied the Kaplan-Meier curve to data from the national database on marriages and divorces in Malaysia, with a total of 1,200 respondents. The results indicate that age at marriage and education play a key role in marital stability. Divorce rates are higher among couples who marry at younger ages and among those with lower educational levels.

Abdel-Sater (2022) used the Kaplan-Meier curve, as one of the survival analysis methods for marriages, to assess the duration of marriages and identify factors contributing to divorce. The focus of his research was on 4 states within the USA, observed over a 35-year period. The analysis results showed that numerous social and economic factors significantly affect the duration of marriages. The work also emphasised the great potential that survival analysis models have in social sciences.

METHODOLOGY

Survival analysis using the Kaplan-Meier curve is a statistical technique used to estimate the probability of survival over a specified period, considering the time until an event, such as death, recovery, recurrence of a disease, or, in this case, divorce. This method uses censored data, which means that event data is not available for some participants by the end of the study (e.g., some participants did not experience divorce during the study period). The Kaplan-Meier curve, displayed as a step function, shows the probability of survival (or event avoidance) at any given time. It is a

standard statistical tool used in survival analysis, frequently employed in fields such as epidemiology, medicine, and social sciences. More details on survival analysis and Kaplan-Meier curve can be found in Kleinbaum & Klein (2012), Hosmer et al. (2008), and Collett (2015).

One of the key advantages of the Kaplan-Meier method is its applicability when data is incomplete or when event time data differs among participants. The method is robust and can accommodate data related to different follow-up periods, which is often the case in medical, epidemiological, and social research.

The Kaplan-Meier curve is beneficial for researchers as it clearly illustrates 'time to event' and enables the identification of points where significant survival drops occur. For example, in divorce research, it is possible to identify a period (e.g., the first five years of marriage) when the likelihood of divorce is higher, which can assist in designing appropriate interventions. The graphical representation of the Kaplan-Meier curve provides a straightforward visualisation of survival across different groups, facilitating conclusions about which factors increase or decrease the risk of an event. In this way, the Kaplan-Meier method helps in quantifying and comparatively analysing risks across different demographic, social, or clinical groups.

Accordingly, the Kaplan-Meier curve is a key tool in survival analysis, enabling the assessment of event probability over time and offering researchers a useful way to visualise survival within groups with different characteristics.

The application of the Kaplan-Meier curve in this study focuses on marriages contracted in the Republic of Serbia between 2011 and 2022. The marriage database relates to the divorce database from the same period. In this way, data suitable for survival analysis is consolidated in one place, allowing for each marriage recorded between 2011 and 2022 to determine whether it was dissolved in the same period and, if so, how long it lasted. The data source is the database of the Statistical Office of the Republic of Serbia (RZS), which, in its official capacity, collects and processes data on all marriages contracted within the state via form DEM-3, as well as all dissolved marriages (form RB-1). RZS data is anonymised to protect the identities of observed entities. Data preparation and the entire analysis were performed in the R software package, where the 'survival' command package was used for survival analysis and the creation of the Kaplan-Meier curve.

Thus, a unified database was created, where it is recorded whether each marriage was dissolved in the meantime and, if so, how long the dissolved marriage lasted. After organising the database, a total of 411,978 observations (marriages) were obtained, of which 24,240 were dissolved, and survival analysis was conducted on them. The time to event is known for couples who divorced during the observed period (2011-2022). For

other couples, divorce did not occur during the observation period, meaning their marriage duration is longer than the observation period. For these specific cases, only censored time is available. Censored time may represent the time until study withdrawal, death, or observation end, representing right-censored units in the context of survival analysis.

RESULTS

Descriptive Data Analysis

In the dataset of 411,978 marriages, considering previous marital status, 5,140 (1.25%) grooms were identified as widowers, and 49,915 (12.12%) were previously divorced men. For brides, there were 4,611 (1.12%) widows and 48,126 (11.68%) previously divorced women. Among grooms and brides, there were cases with previous marriages, where none had more than two prior marriages. The average age of grooms at marriage was 33.29 years (median is 31 years). The median is a measure of central tendency that separates a dataset (in this case the grooms acording to their age) into two equal halves when the data is arranged in ascending or descending order (50% of grooms are younger that 31 years, while the other 50% is older than 31 years). The average age of brides at marriage was 29.98 years (median is 28 years). The average age difference between spouses was 3.3 years (median is 3 years). The annual number of marriages from 2011 to 2022 is presented in Figure 3.

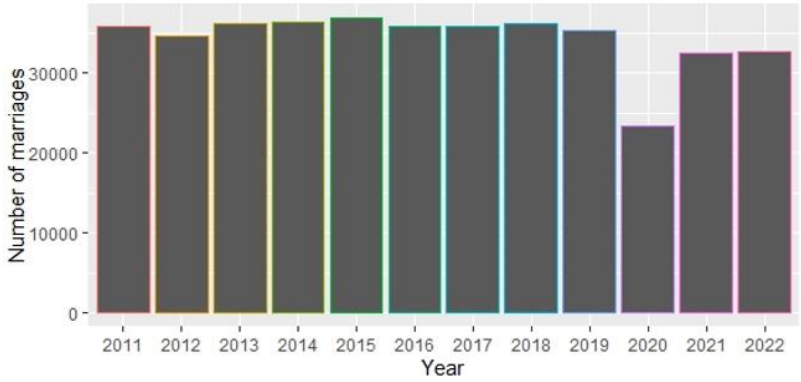

Figure 3. Number of marriages per year from 2011 to 2022
Source: Authors

Before marriage, 84,281 couples (20.46%) reported living together in a non-marital union, while 179,443 (43.56%) stated they did not. The remaining couples did not disclose their living arrangements. Regarding citizenship, 395,950 grooms (96.11%) held the citizenship of the Republic

of Serbia, while for brides, this number was 393,946 (95.62%). In terms of age differences, in 40,442 marriages (9.82%), spouses were the same age, in 291,543 cases (70.77%), the groom was older, and in 75,746 cases (18.39%), the bride was older. For educational level differences, in 266,604 marriages (64.71%), there were no differences in education levels between spouses, while in 145,374 marriages (35.29%), differences existed. Given that the statistical form filled out distinguishes up to 10 levels of education (from no formal education to doctoral level), the number of couples with identical education levels was exceptionally high.

Among divorced marriages only (24,240 cases), the average age of divorced men was 37.16 years (median 35 years), while for women, the average was 33.54 years (median 32 years). The average duration of a dissolved marriage contracted between 2011 and 2022 was 4.02 years. The average age difference among divorced couples was 3.55 years. The number of divorces by the year of marriage from 2011 to 2022 is presented in Figure 4.

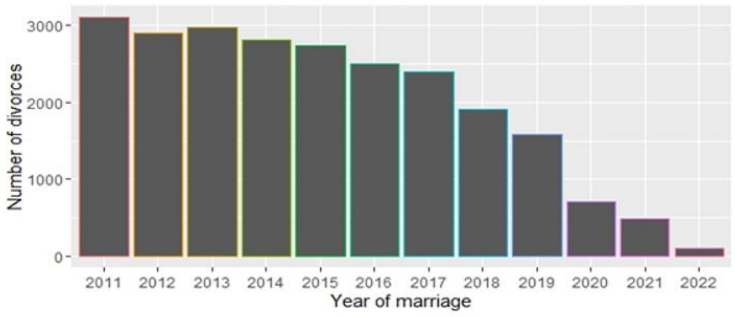

Figure 4. Number of divorces by the year of marriage, from 2011 to 2022
Source: Authors

Among the divorced marriages, in 11,787 cases (48.63%) children were born within the marital union, and in 3,187 cases (13.15%), children were born outside of the observed marriage. Educational differences among divorced couples were absent in 15,603 cases (64.37%), while they were present in 8,637 cases (35.63%), closely matching the proportions found in marriages overall.

The Kaplan-Meier Curve

The following table (Table 1) and graph (see Figure 5) display the results of the analysis using the Kaplan-Meier curve. The survival table shows the analysis progression, from the first to the last time period, with the number of marriages observed and the number of divorces from the first up to the eleventh year of marriage.

Table 1. Survival table

Time in years	Number of cases at risk	Number of events	Survival probability	Standard error	Lower 95% CI	Upper 95% CI
1	411978	4438	0.989	0.000161	0.989	0.990
2	342942	3978	0.978	0.000241	0.977	0.978
3	316223	3595	0.967	0.000301	0.966	0.967
4	278834	3170	0.956	0.000355	0.955	0.956
5	241387	2569	0.945	0.000404	0.945	0.946
6	205287	2083	0.936	0.000452	0.935	0.937
7	169855	1627	0.927	0.000499	0.926	0.928
8	134068	1185	0.919	0.000548	0.918	0.920
9	99303	834	0.911	0.000605	0.910	0.912
10	65246	505	0.904	0.000677	0.903	0.905
11	32990	256	0.897	0.000801	0.895	0.899

Source: Authors' calcultaion

A detailed explanation of each column and its significance is the folowing: 'Time in years' (years of marriage) represents the number of years since marriage, and each row corresponds to a specific year in the observed period (from the 1st to the 11th year of marriage); 'Number of cases at risk' indicates the number of marriages still at risk of divorce at the beginning of each time period, and this number decreases over time as marriages either continue (survive) or end in divorce; 'Number of events' (divorces) shows the number of marriages that ended in divorce in the corresponding time period, and a higher number suggests a period with more frequent divorces; 'Survival probability' represents the estimated probability that a marriage will survive past a given time point. The value is cumulative, meaning it decreases as time progresses, indicating a decline in marriage stability. For example, after 1 year, the survival probability is 0.989 (98.9%), meaning that 98.9% of marriages remain intact, while by year 11, it has dropped to 0.897 (89.7%). 'Standard error' measures the statistical uncertainty of the estimated survival probability, and smaller values indicate greater precision in the survival estimate; the Lower and Upper 95% confidence interval (CI) represent the range within which the true survival probability is expected to lie with 95% confidence. A narrow confidence interval suggests a more precise estimate, while a wider interval suggests greater uncertainty. For instance, after 6 years, the survival probability is 0.936, with a lower bound of 0.935 and an upper bound of 0.937, indicating high precision.

The Kaplan-Meier curve provides a clear overview of the probability of marriage duration over time, from the first to the eleventh period. The horizontal axis in the diagram represents the time until the event. In this diagram, the survival curve drops after the recorded number of divorces in the current year. The vertical axis represents the probability of marriage survival.

When interpreting the curve, it is important to pay attention to its steepness, which indicates the divorce frequency – the steeper the curve, the higher the divorce rate. Since the curve in this case has a relatively gradual decline (Figure 5), it can be concluded that the divorce rate is relatively low.

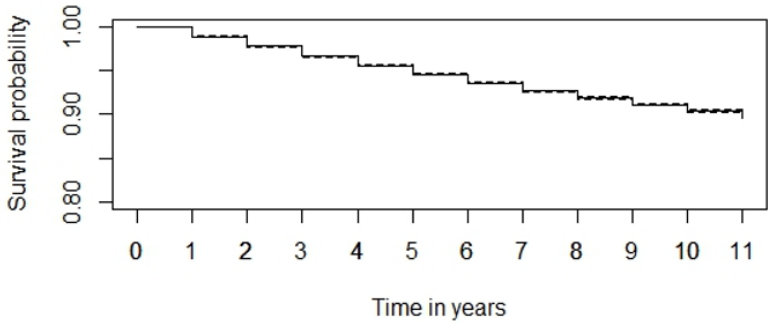

Figure 5. Kaplan –Meier curve
Source: Authors

The Kaplan-Meier curve highlights the stability of marriages in Serbia, especially during the early years. It shows that 98.9% of couples remain married after the first year, and 97.8% by the second year, demonstrating a low divorce rate initially. The survival probability then gradually declines to 89.7% by the eleventh year, indicating a higher risk of separation as marriages progress. This pattern suggests that while marriages in Serbia start off stable, they face increasing challenges over time.

Further analysis of the curve reveals that the decline in marriage survival probability gradually increases, yet the overall trend remains stable, with a survival probability of 89.7% in the eleventh year. This may result from various social, economic, or cultural factors affecting marriage duration, such as family relationships, economic stability, or social pressures.

It is also important to note the way the vertical axis of the graph is set, with starting values from 0.8 instead of 0. The vertical axis is shortened, showing the probability from 0.8 to 1, rather than from zero, to better visualise the shape of the curve. Without this adjustment, the slope would appear even flatter. This approach simplifies the visual interpretation of the curve shape, especially when changes are minor. However, this technique may make direct comparison with other analyses using the full vertical axis range more challenging.

CONCLUSION

Compared to many Western European countries, the divorce rate in Serbia has traditionally been lower due to conservative social norms, strong family ties, and the role of religion in people's lives. However, over the past few decades, the divorce rate has gradually increased, following broader European trends and specific changes within Serbian society. As the number of divorces in Serbia rises, this topic is becoming increasingly researched, as is the application of advanced techniques to improve predictive measures. In this study, we explored an approach using survival analysis to predict marital dissolution and provided a detailed application of marital prediction using the Kaplan-Meier curve to address the issue of data censoring in time series.

A significant advantage of this study over others is the size of the observed dataset, which has not been recorded in any major divorce research worldwide and includes over 400,000 marriages. Essentially, this is a census of marriages in one country over an eleven-year period. The results of this study would be further improved and more significant if economic indicators that substantially influence marriage preservation, such as household income, housing conditions, and so on, were available. Additionally, some important demographic factors are missing, such as the number of children born within and outside of marriages that were not dissolved, cohabitation with the parents of the spouses, whether the parents of the spouses are divorced, and so on. However, this data is not collected in the official statistics on marriages and divorces.

The results of this research have important implications for future research directions, as well as for creating policies that may support marital stability in Serbia. Further investigation is needed into the impact of cultural and social norms on divorce rates to better understand the specificities of Serbian society in this context. It is also essential to study the role of economic factors more extensively, especially considering new economic and social challenges.

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ПРИМЕНА КАПЛАН-МАЈЕР МЕТОДЕ У АНАЛИЗИ СТАБИЛНОСТИ БРАКОВА У СРБИЈИ

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Резиме

Студија, приказана у раду, користи Каплан-Мајер криву, као важну статистичку технику анализе преживљавања, а све са циљем да процени вероватноћу опстанка бракова у Србији посматраних у периоду од 11 година (од 2011. до 2022. године). Узорком су обухваћени подаци које је прикупио Републички завод за статистику Србије, а који броје преко 400.000 посматраних бракова и 24.240 развода у посматраном периоду. Иако су стопе развода у Србији традиционално ниже, у поређењу са осталим европским земљама због конзервативних друштвених норми, породичних веза и улоге религије, примећен је тренд постепеног раста истих. Овај тренд је последица промена унутар српског друштва и сличан је ширим европским трендовима.

Економски криза и политичка нестабилност 90-их, као и оружани сукоби на простору бивше Југославије, допринели су паду стопе бракова, док су стопе развода наставиле да расту због стреса изазваног неизвесношћу и економским тешкоћама. У 2000-им, стопе бракова полако су се опоравиле, али су остале ниже него пре 90-их, док су стопе развода достигле врхунац. Многи парови одлучили су да се касније венчају, смањујући укупан број бракова, док је све више парова изабрало заједнички живот без формалног венчања, одражавајући промене у друштвеним нормама.

Пандемија КОВИД-19 такође је имала значајан утицај на стопе бракова и развода. Током пандемије, многи парови су одлучили да одложе венчања због ограничења окупљања и економске неизвесности, док су се кућни изазови повећали, доводећи до пораста развода у неким случајевима. Пандемија је додатно истакла важност економских фактора у стабилности бракова, будући да су парови који су се суочавали са економским притисцима чешће разматрали развод.

До 2022. године, стопа бракова у Србији остала је релативно ниска у поређењу са средином 20. века, док су стопе развода стабилизоване на вишем нивоу него у претходним деценијама. Иако брак остаје важна институција у српском друштву, све већи број парова бира заједнички живот без формалног венчања, што одражава промену ставова према традиционалним облицима партнерства.

У овом раду коришћена је Каплан-Мајер метода за анализу цензурисаних података у временским серијама, са циљем проучавања трајања (опстанка) бракова у Србији током посматраног периода. Налази ове студије имају значајне последице за будућа истраживања и развој политика које би могле да унапреде стабилност бракова у земљи. Даљу истраживачку пажњу треба посветити испитивању утицаја културних и друштвених фактора на стопе развода, што би допринело бољем разумевању карактеристика српског друштва у том контексту.