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The impact of Black Swan events on migration inflows: evidence from Poland's COVID-19 experience

Wpływ zdarzeń typu „czarny łabędź" na napływ migrantów: doświadczenia Polski w czasie pandemii COVID-19

Abstract. This study aims to examine whether the COVID-19 pandemic functioned as a Black Swan event that fundamentally altered international migration flows into Poland. Using comprehensive data on residence applications from 229 countries and country-level entities between 2010 and 2024, we conducted a descriptive year-on-year analysis to identify structural breaks in migration patterns. The results show that the pandemic's onset corresponded with the lowest migration growth in the time series, followed by an unprecedented surge in migrant inflows that greatly exceeded pre-pandemic trends. These findings demonstrate that COVID-19 not only disrupted but restructured migration dynamics, highlighting the pandemic's role as a rare, high-impact event with lasting consequences. By applying the Black Swan framework to human migration, this study provides a novel theoretical lens for understanding how global shocks can transform mobility systems. These findings have important implications for migration policy planning and forecasting, suggesting that models must account for rare, high-impact disruptions rather than relying solely on historical trend extrapolation.

Keywords: COVID-19, Black Swan event, international migration, Poland, rare events, migration policy, structural breakdown

Synopsis. Celem artykułu jest rozpoznanie, czy pandemia COVID-19 funkcjonowała jako zdarzenie typu „czarny łabędź", fundamentalnie zmieniające międzynarodowe przepływy migracyjne do Polski. Wykorzystując kompleksowe dane dotyczące wniosków o pobyt z 229 krajów i jednostek terytorialnych złożonych w latach 2010–2024, przeprowadzono opisową analizę rok do roku w celu zidentyfikowania strukturalnych zmian we wzorcach migracyjnych. Wyniki pokazują, że początek pandemii odpowiadał najniższemu wzrostowi migracji w szeregu

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czasowym, po którym nastąpiło bezprecedensowe zwiększenie napływu migrantów, znacznie przekraczające trendy sprzed pandemii. Uzyskane wyniki dowodzą, że COVID-19 nie tylko zakłócił, ale także zrestrukturyzował dynamikę migracji, co podkreśla rolę pandemii jako rzadkiego zdarzenia o dużym wpływie i długotrwałych konsekwencjach. Dzięki zastosowaniu modelu „czarnego łabędzia" do migracji ludności niniejsze badanie dostarcza nowatorskiej perspektywy teoretycznej pomagającej zrozumieć, jak globalne wstrząsy mogą przekształcać systemy mobilności. Zaobserwowane zjawisko ma istotne implikacje dla planowania i prognozowania polityki migracyjnej, sugerując, że tworzone modele muszą uwzględniać rzadkie zakłócenia o dużym wpływie, a nie polegać wyłącznie na ekstrapolacji trendów historycznych.

Słowa kluczowe: COVID-19, czarny łabędź, migracje międzynarodowe, Polska, zdarzenia rzadkie, polityka migracyjna, przełamanie strukturalne

Kody JEL: F22, J61, O52, E65

Introduction

Throughout history, pandemics have functioned as rare, high-impact disruptions to the normal course of human events. The influenza pandemic of 1918–1920, often referred to as the Spanish flu, and earlier outbreaks of influenza serve as prominent examples of what Nassim Nicholas Taleb terms Black Swan events: occurrences that are extremely rare, have severe consequences, and are often rationalized only in hindsight [Phan and Wood 2020]. These events are characterized by their capacity to reshape societal, economic, and demographic patterns in ways that were previously unanticipated [Siudak and Świetlik 2025].

COVID-19, which emerged in late 2019, represents the most profound Black Swan event of the 21st century to date. The pandemic's status as a Black Swan has been widely acknowledged across disciplines: in economic development (where it triggered unprecedented global contractions) [Mishra 2020], health sciences (where it overwhelmed medical systems) [Mazzoleni et al. 2020, Fiorini and La Gioia 2021], business management (where it disrupted global supply chains) [Enz et al. 2024], futures studies (as a case study in unforeseen systemic risk) [Sweeney 2022], and macroeconomics (where it generated simultaneous shocks to both unemployment and inflation) [Hysa et al. 2022]. The breadth and depth of COVID-19's impact set it apart as a global disruptor of exceptional scale.

In the domain of international migration, COVID-19's effects have been similarly profound. A growing body of research has examined how the pandemic reshaped mobility patterns, with topics including the suspension of labor migration programs, the redirection of student and family reunification flows, as well as the impact on the most vulnerable migrant groups such as irregular migrants and refugees [McMahon et al. 2025, Kugiel 2021, Guan et al. 2024]. Much of this work, however, has focused on documenting immediate disruptions and quantifying temporary declines in cross-border movement. Comparatively little attention has been given to conceptualizing COVID-19's impact on human migration through the theoretical lens of the Black Swan.

Outside of the COVID-19 context, while the Black Swan metaphor has occasionally been applied in studies of animal migration in the context of environmental shocks [Youngflesh and Lynch 2017, Anderson et al. 2017], its application to human migration remains rare, if not nonexistent. This paper seeks to address this gap by positioning COVID-19 as a Black Swan event that fundamentally altered the trajectory of international migration flows into Poland. By doing so, it offers a novel perspective that bridges migration studies with the broader literature on systemic shocks and rare event theory.

The aim of this study is to examine whether COVID-19 functioned as a Black Swan event that fundamentally altered international migration flows into Poland, and to quantify the magnitude and persistence of these changes using comprehensive migration data from 2010 to 2024. Specifically, this paper analyzes year-on-year changes in migrant inflows to Poland between 2010 and 2024. It focuses on the structural break introduced by COVID-19 and its aftermath, using paired difference analysis to quantify shifts in migration patterns. In doing so, we aim to demonstrate how the pandemic not only temporarily restricted mobility but also set the stage for an accelerated surge in migration inflows that would have been difficult to predict beforehand, which is a hallmark of a Black Swan event.

COVID-19 and mobility in Poland

The outbreak of COVID-19 in early 2020 brought human mobility across the globe to an abrupt halt. Poland, like most countries, implemented strict quarantine measures, personal hygiene promotion, and border closures designed to curb the spread of the virus [Hoffmann et al. 2023, Korinth 2022, Sroka 2021]. These interventions fundamentally reshaped the daily lives of individuals and the functioning of institutions. Education transitioned rapidly to online learning, with schools and universities shifting to remote classes [Gajderowicz and Jakubowski 2024]. Businesses adopted remote work arrangements where feasible, while non-essential sectors saw widespread closures or operational restrictions [Szczepański and Zamęcki 2024]. Medical services, too, faced unprecedented challenges as resources were reallocated to the pandemic response and routine care was delayed or suspended [Mularczyk-Tomaczewska et al. 2022, Jaroń et al. 2022, Piątkowska et al. 2021].

From an economic standpoint, Poland experienced both common and distinctive consequences of the pandemic. Inflation was volatile, dropping during the crisis and rising after the crisis, in line with global trends of disrupted supply chains and increased costs of goods and services [Grabia 2022, Ćwiąkała-Małys and Mościbrodzka 2023, Jałtuszyk 2024]. Mortality rates in Poland during the pandemic displayed a mixed profile [Basiak-Rasała et al. 2024, Herman 2022], reflecting both the direct health impact of the virus and the indirect consequences of strained healthcare systems [Mrożek-Gąsiorowska 2023]. However, Poland distinguished itself within the European Union and the OECD by maintaining a relatively strong macroeconomic performance [Bukowski and Paczos 2021]. The Polish economy recorded resilient GDP growth in the recovery period and kept unemployment at comparatively low levels [Pancer-Cybulska 2021, Bartosik 2024]. Firms operating in sectors that are key to the Polish economy, like Information

Technology services, reported increased revenues [Kuryłek and Shachmurove 2025]. This economic stability during and after the pandemic was consistent with Poland's solid performance prior to the COVID-19 crisis [WBJ 2024]. Therefore, we argue that it is contributing to Poland's attractiveness as a destination for migrants in the post-pandemic period.

Importantly, the immediate effect of COVID-19 on migration was to restrict movement dramatically. Border closures, suspension of visa processing, the interruption of regular international travel pathways, as well as a pandemic-induced pause on job offers, halted both temporary and permanent migration flows [Stelmakh et al. 2023, Dudek 2021, Adamczyk et al. 2022]. Yet, as restrictions were lifted and emergency measures phased out, many countries faced an expected migration dynamic: one characterized by a migration rebound trend, and even possibly, by an intensified and accelerated inflow of migrants surpassing that of the pre-pandemic level [IOM 2024, Frey 2025, Benton et al. 2024, Rourke 2020]. It is valuable to see if such a phenomenon is observable in Poland.

Data and methods

We draw on official migration data covering the period from 2010 to 2024, comprising the number of residence applications by foreigners in Poland from 229 different countries and country-level entities or economies of origin [Poland Immigration Services 2025]. The dataset provides annual counts of new migrants by country of origin, enabling an analysis of both absolute numbers and relative year-on-year changes in migration flows over time. This temporal coverage allows for a meaningful comparison of migration trends before and after the onset of COVID-19, with particular attention to the structural break introduced by the pandemic.

In this analysis, 2020 is treated as the onset of COVID-19, marking the initial impact of the pandemic on migration flows. We based our decision to treat 2020 as the year of COVID-19 onset based on various past research on issues surrounding migration during the COVID-19 pandemic [Perales and Bernard 2022, Korczyński and Kajdanek 2024, Xing et al. 2020]. This classification reflects both the global spread of the virus and Poland's immediate responses, including border closures, visa processing suspensions, and lockdowns.

The primary focus of the analysis is descriptive. Several key indicators were calculated to characterize migration trends:

1. The mean number of migrants per year
2. The mean difference in migrant numbers between the preceding and following years
3. The rate of change (percentage difference between years)

Importantly, since the dataset covers all countries of origin present in the official migration records, the means reported represent actual population means, not sample estimates. As such, inferential statistics were neither necessary nor applied. We based this on the theory of inferential statistics; such analysis can be used in the event where the available data is only a sample and not the whole population [Starbuck 2023]. In this case, we use descriptive statistics instead, as they directly reflect the full picture of the analysis from the available data [Dong 2023].

To complement the descriptive analysis, paired difference statistical testing (either a paired t-test or paired Wilcoxon signed-rank test, depending on whether the assumption regarding normality of differences is fulfilled) [Cleophas and Zwinderman 2016] was conducted as a robustness check to assess whether the observed year-on-year changes were statistically meaningful. Below are the steps of the analysis:

1. The Shapiro-Wilk test was applied to evaluate the normality of year-on-year differences [Mishra et al. 2019]. Results showed significant deviations from normality across most year pairs, violating the assumptions required for paired *t*-tests. The *p*-value threshold for non-normality is 0.05.
2. The Wilcoxon signed-rank test, a non-parametric alternative that does not assume normality, was used to test whether median differences between the preceding and following years were significantly different from zero [Pagano et al. 2022]. The *p*-value threshold for meaningful year-on-year differences is 0.05.

These statistical tests provide additional confirmation that the changes observed were not random fluctuations, but reflected systematic shifts in migration flows associated with the COVID-19 Black Swan event.

All statistical tests were conducted in *R*. Below is the step-by-step method in *R*, as well as the *R* scripts used:

1. Upload the dataset into *R*
   R script: migrantsinpoland <- read.csv("Migrants per Countries of Origin in Poland.csv")
2. Create a variable to store the differences between the preceding year (e.g., 2023) and the following year (e.g., 2024)
   R script: diff20232024 <- migrantsinpoland$X2023 – migrantsinpoland$X2024
3. Perform the Shapiro-Wilk test on the difference variable to check normality. If the difference is normal, perform a paired t-test; otherwise, use a paired Wilcoxon test
   R script: shapiro.test (diff20232024)$p.value
4. In all countries, the normality assumption was violated; therefore, the paired Wilcoxon test was used
   R script: wilcox.test(migrantsinpoland$X2023, migrantsinpoland$X2024, paired= TRUE)$p.value
5. Calculate the mean of each year (e.g., 2023)
   R script: mean(migrantsinpoland$X2023)
6. Calculate the mean difference between the preceding year and the following year
   R script: mean (migrantsinpoland$X2024 – migrantsinpoland$X2023)
7. Calculate the change rate between the preceding year and the following year
   R script: (mean(migrantsinpoland$X2011) – mean(migrantsinpoland$X2010)) / mean (migrantsinpoland$X2010)
8. Repeat steps 1 to 7 for all years

Results

As presented in Table 1, the year-on-year analysis of migrant inflows to Poland between 2010 and 2024 reveals clear structural shifts coinciding with the onset of COVID-19. Across the entire period, the mean number of migrants increased steadily, with the annual mean rising from approximately 333 in 2010 to nearly 3,887 in 2024.

Table 1. Year-on-year statistical analysis of the number of residence applications by foreigners in Poland
Tabela 1. Analiza statystyczna liczby wniosków o pobyt składanych przez cudzoziemców w Polsce w ujęciu rok do roku

Year-on-year	Shapiro-Wilk P (year-on--year differences)	Wilcoxon P	Mean (following year-preceding year)	Mean (preceding year)	Mean (following year)	Change rate
2010/2011	4.15E-28	4.33E-13	38.24	332.84	371.09	11.49%
2011/2012	3.18E-29	2.24E-12	52.58	371.09	423.67	14.17%
2012/2013	2.03E-28	2.61E-07	37.43	423.67	461.10	8.83%
2013/2014	1.78E-29	4.92E-07	42.39	461.10	503.48	9.19%

Source: own elaboration
Źródło: opracowanie własne

Figure 1 illustrates this steady growth pattern across the entire time series. However, the pace and magnitude of year-on-year changes varied markedly between the pre-pandemic and post-pandemic periods.

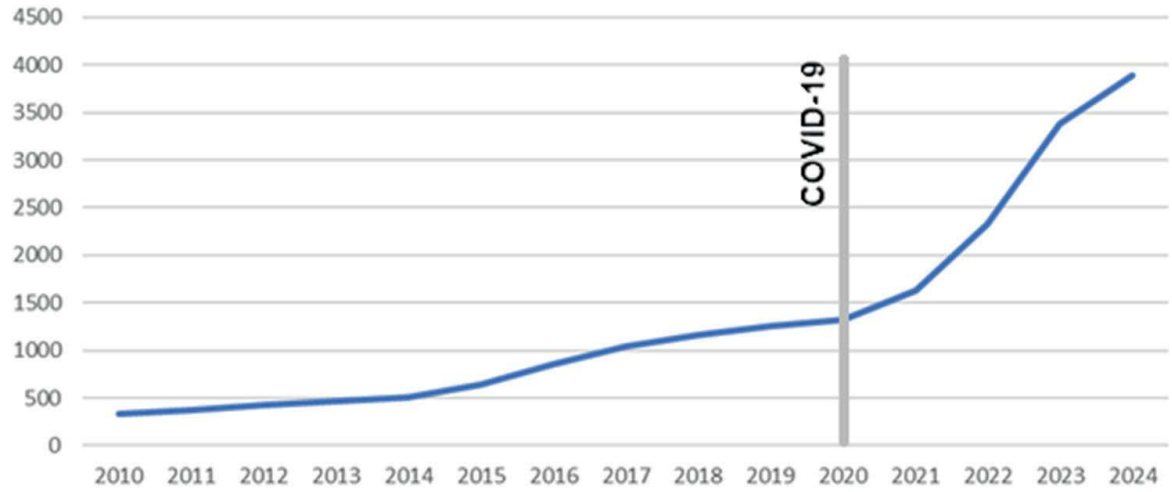

Figure 1. Mean per country (number of residence applications by foreigners in Poland), year-on-year
Rysunek 1. Średnia na kraj (liczba wniosków o pobyt złożonych przez cudzoziemców w Polsce), rok do roku

Source: own elaboration
Źródło: opracowanie własne

Year-on-year differences and change rates

During the pre-COVID period (2010/2011 to 2019/2020), the mean difference in migrant numbers between consecutive years was relatively modest. Annual increases ranged from approximately 38 to 213 migrants, with change rates generally below 15% in

most years. Notable exceptions occurred in 2014/2015 and 2015/2016, where the change rates reached 27% and 33%, respectively.

The year 2019/2020, representing the onset of COVID-19, recorded the lowest change rate in the entire series at just 5.60%, reflecting the immediate disruptive impact of the pandemic on international migration flows.

In stark contrast, the post-COVID period (2020/2021 to 2023/2024) exhibited substantially larger year-on-year differences. The mean difference between consecutive years rose dramatically, peaking at over 1,063 migrants in 2022/2023. Correspondingly, change rates surged to 22.92% in 2020/2021, 42.66% in 2021/2022, and 45.79% in 2022/2023. While the 2023/2024 change rate moderated to 14.78%, it remained elevated compared to most pre-pandemic years.

As shown in Figure 2, this confirms that post-pandemic migration inflows increased not only in absolute terms but also at a significantly accelerated pace relative to the pre-pandemic trend.

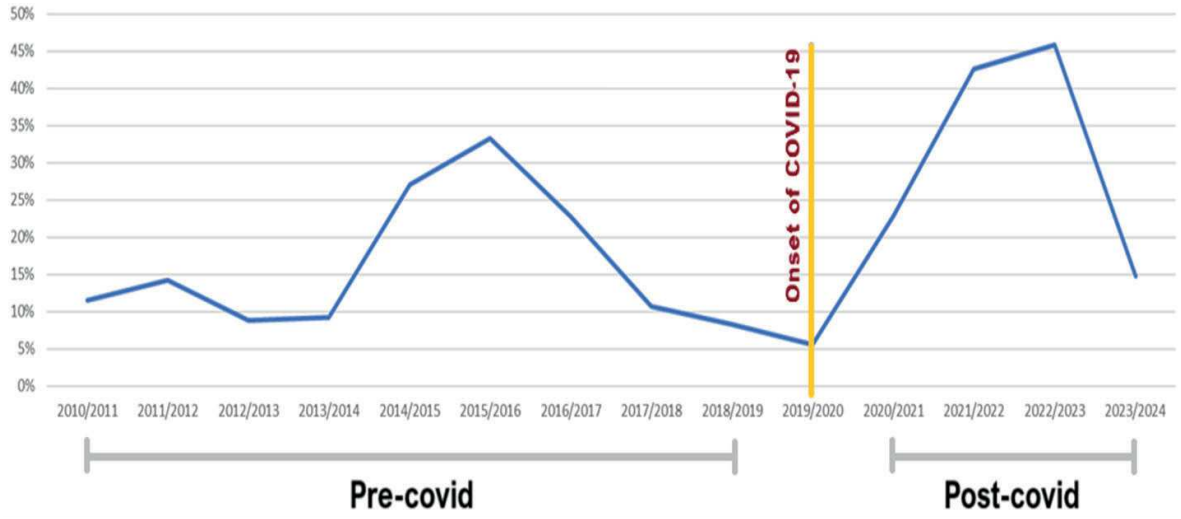

Figure 2. Year-on-year change rate of the number of residence applications by foreigners in Poland
Rysunek 2. Dynamika zmian liczby wniosków o pobyt składanych przez cudzoziemców w Polsce

Source: own elaboration
Źródło: opracowanie własne

Statistical significance of year-on-year differences

The Shapiro-Wilk test for normality consistently yielded p-values far below 0.05, indicating significant departures from normality in the year-on-year differences. As a result, the Wilcoxon signed-rank test was applied across all year pairs.

The Wilcoxon test confirmed that year-on-year changes were statistically significant ($p < 0.05$) for nearly every pair of years, including the low-growth 2019/2020 period ($p \approx 0.024$). This reinforces the conclusion that observed migration differences reflect meaningful structural shifts rather than random variation.

Discussion

The results of the analysis provide compelling evidence that the COVID-19 pandemic acted as a Black Swan event that disrupted and ultimately transformed migration inflows into Poland. The data demonstrate that the pandemic's onset in 2020 corresponded to an immediate and unprecedented slowdown in migration growth, as reflected in the lowest recorded change rate (5.60%) between 2019 and 2020. However, this interruption was followed by an equally unprecedented acceleration in migration inflows, with year-on-year mean differences and growth rates far exceeding those observed in the pre-pandemic decade. The average year-on-year increase in the post-pandemic period (2020/2021 to 2023/2024) was around six times greater than that in the pre-pandemic years (2010/2011 to 2018/2019), underscoring the pandemic's long-lasting and transformative impact. Figure 3 clearly demonstrates the comparison of change rates between pre-, during, and post-pandemic periods.

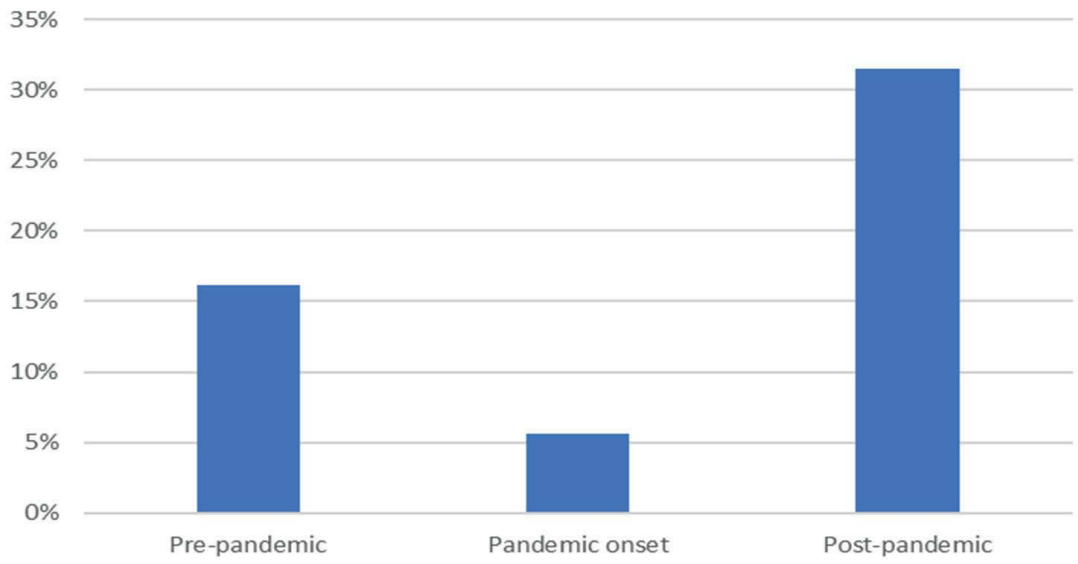

Figure 3. Comparison of the change rate in the number of residence applications by foreigners in Poland between pre-, during, and post-pandemic periods

Rysunek 3. Porównanie tempa zmian w liczbie wniosków o pobyt składanych przez cudzoziemców w Polsce przed pandemią, w trakcie i po jej zakończeniu

Source: own elaboration

Źródło: opracowanie własne

COVID-19 as a Black Swan in migration dynamics

These findings support the interpretation of COVID-19 as a Black Swan event in the context of international migration to Poland. According to Taleb's framework, Black Swan events are defined by their rarity, extreme impact, and retrospective predictability, all of which are characteristics that align closely with the pandemic's migration consequences. The sudden and massive disruption of international mobility in 2020, we argue, was beyond the scope of prior expectations and projections. Likewise, we also argue that the post-pandemic surge in migration inflows, which outpaced pre-pandemic

growth trends by a wide margin, was not foreseen in standard migration forecasts. The pattern revealed in this paper reflects not simply a temporary rebound to previous levels but a structural shift in migration dynamics that was catalyzed by the pandemic's systemic shock.

While some scholars argue that pandemics like COVID-19 were predictable based on historical precedent, scientific warnings, and existing pandemic preparedness literature [WHO 2019, Gates 2015], our findings support the Black Swan interpretation specifically for migration systems. The critical distinction lies not in the pandemic's biological emergence, which experts had indeed warned about, but in its unprecedented magnitude of impact on human mobility patterns.

Three key pieces of evidence support this Black Swan characterization for migration: First, the dramatic structural break we observed, where post-pandemic annual increases averaged six times greater than pre-pandemic levels, was not anticipated by existing migration forecasting models or policy frameworks. Second, the specific pattern of initial collapse followed by an exponential acceleration created migration dynamics that had no historical parallel in Poland's modern migration experience. Third, the persistence and scale of change (continuing through 2024) demonstrates that COVID-19 did not merely disrupt migration temporarily but fundamentally reconfigured the entire system in ways that could not have been extrapolated from pre-2020 trends.

This shows that, while the pandemic itself may have been foreseeable as a general risk, its specific transformative impact on Poland's migration system exhibits the hallmark unpredictability and disproportionate consequences that define Black Swan events in Taleb's framework.

Microeconomic explanations: individual motivations to migrate

The migration surge following the lifting of restrictions can be partly attributed to individual-level motivations that intensified during the pandemic period:

a. Intention to re-migrate

Many previous migrants who had returned to their home country prior to or during the early stages of the pandemic were looking to come back to Poland. This remigration process, although not confirmed by research empirically in Poland, is present elsewhere around the world [Sen et al. 2023]. There is a tendency for return migrants to re-migrate to the country to which they had previously settled prior to the COVID-19 pandemic [Sen et al. 2019].

b. Use of social media

Lockdowns confined people to their homes for extended periods, during which social media and other digital platforms became primary windows into the outside world. Exposure to idealized representations of life in countries with stable socio-economic conditions may have heightened aspirations for migration among people from less developed countries. In this sense, migration desire was not merely preserved during the pandemic but may have been intensified as individuals "lived elsewhere" vicariously through their screens. This is especially relevant if we consider past research, which has seen the use of social media in their native language increase among migrants and ethnic minorities living abroad [Goldsmith et al. 2022].

Macroeconomic explanations: policy changes

At the structural level, several policy factors contributed to the magnitude of post-pandemic migration inflows:

a. Regulatory easing

The reopening of the border post-pandemic may have increased the number of migrants to Poland. This has happened elsewhere in countries that have traditionally been the destination for international migration [Diehn 2021, Kiernan 2023]. In the EU, the border agency Frontex commented that we may witness a dramatic effect, since the region could see an increase in post-pandemic migration, especially after the number of migrants significantly went down during COVID-19 [Diehn 2021]. In Poland, this may have a multiplying effect due to the lifting of the pandemic-related emergency status imposed by the national government in July 2023, which means that migrants who had previously lived in Poland without needing to apply for residence now must do so [Ushakov 2023].

b. Worsened conditions in migrant-sending countries

The COVID-19 pandemic has hit poor countries the hardest, as reported by the World Bank [Nishio 2021]. This is in contrast with EU countries, where the IMF has noted a strong economic recovery post-pandemic [Kammer 2021]. International migrants are drawn to the EU because they have to face worse conditions due to COVID-19. Poland itself is especially attractive in this context, since it remains one of the "best performing economies" in the region, with an 11 percent increase in Q1 2024 compared to pre-pandemic levels [Kalasopatan 2024]. Migration-wise, Poland is set to become a net migrant importer as early as 2030 [Fihel 2023].

Theoretical Contributions

The combination of these micro- and macro-level dynamics illustrates how a Black Swan event like COVID-19 can trigger both immediate disruptions and longer-term systemic transformations. The findings highlight the limitations of linear models of migration forecasting, which are often based on gradual trends and historical precedents. Instead, the data underscore the need for migration research and policy to account for rare, high-impact events that can radically reshape mobility patterns in unexpected ways.

By applying the Black Swan framework to human migration, a domain where it has rarely been used, this study contributes a novel theoretical lens for understanding how global shocks can produce lasting changes in migration systems. It opens new avenues for investigating the resilience, adaptability, and vulnerability of migration pathways in the face of rare but consequential disruptions.

Study Limitations

This study has several limitations that should be acknowledged. Our analysis focuses solely on Poland, limiting generalizability to other national contexts with different migration policies and economic conditions. The descriptive nature of our analysis establishes patterns but does not allow for causal inference about the specific mechanisms driving observed changes.

Additionally, our data captures formal residence applications but may not fully reflect irregular migration flows or temporary movements that did not require official documen-

tation. Finally, while we interpret COVID-19 as a Black Swan event based on Taleb's framework, alternative theoretical approaches to understanding systemic disruptions could provide additional insights into migration dynamics during crisis periods.

Conclusions

This study demonstrates that the COVID-19 pandemic acted as a Black Swan event that fundamentally altered migration inflows into Poland. Our descriptive analysis of comprehensive data covering 2010–2024 shows that COVID-19 first triggered an unprecedented slowdown in migration growth in 2019/2020, before setting the stage for a surge in migrant inflows in subsequent years that surpassed pre-pandemic trends by a wide margin. The scale of year-on-year changes post-pandemic, with average annual increases more than six times those recorded before 2020, underscores the pandemic's transformative impact on Poland's migration system.

These findings support the view that COVID-19's effects on migration cannot be understood solely as a temporary disruption. Instead, the pandemic served as a systemic shock that restructured migration dynamics, reflecting the hallmark unpredictability and outsized consequences of a Black Swan event. By applying this framework to human migration, a domain where it has seldom been explored, we contribute a novel perspective to migration theory and demonstrate the need for integrating rare, high-impact events into analyses of international mobility.

The results highlight the interaction of micro-level drivers, including deferred intentions, heightened aspirations fueled by digital exposure, and the psychological impetus for return migration, with macro-level factors such as labor shortages, regulatory easing, and worsening socio-economic conditions in migrant-sending countries. Together, these forces produced a sharp and lasting reconfiguration of migration flows to Poland after the onset of COVID-19.

From a policy perspective, our findings emphasize the importance of anticipating how rare systemic events can reshape migration patterns in ways that defy incremental forecasting. Policymakers should incorporate contingency planning for such Black Swan events, recognizing that their effects on migration are neither transient nor easily predictable. Future research should extend this approach by examining similar dynamics in other European Union countries and beyond, exploring how differing national contexts mediate the migration consequences of global disruptions.

Ultimately, understanding migration through the lens of Black Swan theory provides a powerful tool for grasping the scale and complexity of transformations that rare but consequential events can impose on human mobility systems.

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