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A SPATIAL OLG MODEL OF REGIONAL RISK: PRODUCTIVITY, MOBILITY, HOUSING AND PENSION TRANSFERS

Purpose. This study aims to develop an advanced dynamic spatial theoretical framework capable of capturing the interactions among regional security conditions, labour mobility, housing-market rigidity, and intergenerational fiscal mechanisms under asymmetric shocks and conflict-related risks. The model is designed to reveal how spatial risk affects the behaviour of economic agents, shapes regional labour-market outcomes and determines the long-run spatial equilibrium of an economy undergoing profound structural disruptions. **Methodology.** The research employs a dynamic spatial overlapping-generations (OLG) model in which individuals optimise choices regarding location, consumption, savings and migration. The model formalises the influence of a regional risk index on productivity, wages, rental prices, locational attractiveness and the functioning of the PAYG pension system. Analytical derivations, including intermediate proofs, demonstrate how security risk monotonically affects key macroeconomic variables and ensure the existence of a dynamic spatial equilibrium with endogenous migration flows. **Results.** The findings show that reductions in regional risk increase effective productivity, raise wages, stimulate inflows of young workers and heighten pressure on inelastic housing markets, producing persistent spatial differentials in rents and wages. Short-run housing rigidity is shown to amplify regional disparities and delay the convergence of economic conditions. The study further establishes that shifts in the spatial allocation of labour alter the fiscal balance of the PAYG pension system, generating new interregional distributional tensions. **Scientific novelty.** The study introduces a fully integrated framework in which the security indicator simultaneously acts as an amenity, a productivity determinant and a discount factor in housing valuation. This enables the identification of a coherent "security multiplier" mechanism that transmits conflict-related shocks through all major markets in the spatial economy. **Practical significance.** The results provide a theoretically grounded foundation for designing post-war recovery strategies, including housing and transport policies, regional development programmes, and pension system reforms. They may also support forecasting exercises and scenario modelling for Ukraine's long-term spatial recovery under varying security trajectories.

Keywords: spatial modelling; regional security; risk, migration; housing market; productivity; PAYG; intergenerational transfers

Problem Statement

Russia's full-scale invasion of Ukraine in 2022 has caused significant regional disparities in security, economic activity, and population displacement. While frontline regions face destruction and depopulation, relatively safer areas, particularly in the west and centre of the country, have become zones of immigration, increased housing demand, and shifts in local labour markets. These uneven spatial shocks raise important questions for economic recovery policy:

1. How do security conditions interact with mobility, housing frictions, and fiscal institutions to influence regional economic dynamics?

2.Can national recovery programmes effectively address such diverse regional needs?

Despite the expanding research on war economics and post-conflict recovery, few formal models have captured the interaction between internal migration, local labour markets, and spatial risks during an ongoing conflict. Ukraine offers a particularly complex case, with millions of internally displaced persons (IDPs), localised security risks that change over time, and limited fiscal capacity. Understanding how individuals and firms respond to spatially differentiated shocks is essential for designing targeted policies that prevent the deepening of regional inequalities and promote long-term resilience.

The importance of this issue extends beyond Ukraine. Climate change, geopolitical instability, and regional conflicts increasingly create asymmetric shocks within national economies- particularly in middle-income or developing countries. Spatial economics and overlapping generations models provide valuable

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insights into how such shocks spread and how policies—such as housing subsidies, infrastructure investments, or interregional transfers—can influence outcomes.

In Ukraine, key national policy tools such as Pay-As-You-Go (PAYG) pension systems, housing support programmes, and infrastructure investments are not inherently spatially targeted. This raises the question: how effectively can centralised redistributive systems operate when regions differ markedly in risk and population movements?

Analysis of recent research and publications

The recent literature addressing our question has developed along three largely parallel tracks: spatial equilibrium and urban economics; quantitative spatial and dynamic geography; and overlapping-generations and conflict-displacement studies. Together, they provide many of the ingredients we need. Still, they do not yet assemble them into a framework well-suited to Ukraine's recovery and the central role of regional security.

A natural starting point is the spatial equilibrium tradition introduced by Roback's [11] analysis of "wages, rents, and the quality of life". In that framework, local amenities and disamenities are collectively capitalised into wages and land rents under full spatial mobility, resulting in compensating differentials that balance utility across locations. Subsequent urban and regional research has examined similar wage–rent–amenity trade-offs, but usually in static contexts with amenities considered as time-invariant or slowly changing. Comprehensive reviews of modern spatial economics, such as Redding and Rossi-Hansberg [10] and Proost and Thisse [9], highlight that contemporary quantitative spatial models can incorporate significant heterogeneity in trade costs, productivity levels, and amenities, and are now routinely employed to assess regional and national policies. However, these models generally omit explicit life-cycle behaviour, social security design, and intergenerational impacts of shocks—all crucial considerations for a country experiencing demographic shifts and large-scale forced population movements.

A second strand has introduced time and spatial dynamics more explicitly. Desmet and Rossi-Hansberg [2] develop a model of "spatial development" in which locations accumulate population and productivity over time and can experience agglomeration or decline. This work demonstrates how geography and dynamics interact to produce persistent regional divergence. Related contributions in quantitative spatial economics study how trade, migration, and local productivity shocks shape the long-term distribution of economic activity. Behrens and Murata [1], for instance, analyse general-equilibrium models of monopolistic competition in space, highlighting how increasing returns and market access can generate multiple spatial configurations. Yet even in this dynamic spatial literature, the focus is typically on infinitely lived agents or representative households, and on productivity or trade shocks rather than on security conditions that differentially affect cohorts and interact with a pay-as-you-go (PAYG) system.

The overlapping-generations tradition, originating from Diamond's [3] influential model of capital accumulation with two-period lives, offers precisely the life-cycle features missing from most spatial analyses: finite horizons, saving for retirement, and the natural incorporation of PAYG social security. OLG models have since become a standard tool for analysing pension reforms, public debt, and intergenerational redistribution. However, they are typically formulated in "aspatial" economies, involving at most a small number of representative countries, and do not account for the reallocation of cohorts across regions within a country, the interaction of that reallocation with regional housing markets, or how security conditions influence productivity and location choices.

The literature most relevant to our context is the growing body of research on conflict, internal displacement, and housing outcomes in and around Ukraine. Perelli-Harris et al. [8] examine subjective well-being among internally displaced persons (IDPs) in Ukraine and residents in 2018, showing that IDPs report significantly lower life satisfaction than locals, and that economic hardship and housing conditions explain a substantial share—though not all—of this gap. Their analysis highlights housing loss, insecure accommodation, and exposure to violence as key channels through which displacement affects welfare. International Organisation for Migration (IOM) [6] reports document the scale and geography of internal displacement and provide descriptive evidence on housing conditions, rental costs, and intentions to move; these reveal strong pressures on rental markets in receiving regions and varied integration outcomes for IDPs [7].

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Closely related work in neighbouring countries shows how forced migration from Ukraine has impacted host housing markets: Trojanek and Gluszak [12] identify a short-term rise in Polish housing prices linked to the refugee influx, while recent research by Gluszak and Trojanek [5] explores broader responses of the housing market to the refugee crisis and war. These studies confirm that conflict-related migration can quickly tighten rental markets, but they are mainly partial-equilibrium analyses and do not account for intertemporal savings or pension systems.

Taken together, these literatures establish several key facts: wages and rents jointly adjust to local amenities and disamenities; spatial dynamics and agglomeration can generate persistent regional divergence; life-cycle and PAYG mechanisms are essential for studying intergenerational incidence; and conflict-induced displacement has considerable, spatially uneven consequences for housing, welfare and, in host countries, property markets.

What is missing is a unifying framework that: (i) treats a regional safety index as a first-order driver of preferences, productivity and housing demand; (ii) embeds location choice for the young into an overlapping-generations structure with PAYG; and (iii) is explicitly conceived as a tool for analysing transitional dynamics of recovery in Ukraine.

Purpose of the Article

The purpose of this article is to develop a coherent theoretical framework that captures the interaction between regional security risks, internal mobility, housing market frictions, and intergenerational fiscal institutions in a conflict-affected economy. Building on insights from spatial equilibrium theory, quantitative spatial models, and overlapping-generations (OLG) macroeconomics, the article proposes a dynamic spatial OLG model tailored to the Ukrainian context.

The model is designed to achieve three central objectives: (1) to formalise how regional safety conditions shape individual location choices, labour allocation, housing demand, and productivity in an economy where mobility is costly and housing supply is short-run inelastic; (2) to integrate intergenerational mechanisms—specifically the functioning of the PAYG pension system—into a spatial framework, thereby allowing for the analysis of how conflict-induced population flows affect fiscal sustainability and distributional outcomes across cohorts; (3) to derive testable implications for post-conflict recovery policies, including housing programmes, infrastructure and transport investments, and measures aimed at restoring safety and reducing spatial risk.

By pursuing these objectives, the article aims to offer a rigorous analytical foundation for evaluating regional recovery strategies in Ukraine and to contribute to broader debates on resilience and policy design in economies exposed to highly asymmetric regional shocks.

The main material of the research

The theoretical structure of the model is built upon a dynamic spatial economy in which overlapping generations of individuals choose where to reside and work. At the same time, firms allocate capital and labour across regions that differ in productivity, security conditions and housing availability. The interconnections among these forces are summarised schematically in Figure 1, which depicts how regional attributes shape wages, rents, population flows and fiscal balances, and how these, in turn, feed back into household and firm decisions.

The diagram serves to emphasise that security risk, productivity and housing-market tightness do not operate in isolation but form a mutually reinforcing system that governs spatial dynamics.

Individuals live for two periods. When young, they supply labour, consume, save and choose a region of residence; in old age, they consume savings and receive a pension financed through a national pay-as-you-go (PAYG) system. A young individual born in region (s) who chooses region (r) in period (t) enjoys lifetime utility.

$$U_{sr,t}(r) = u(c^y r, t) + \beta\pi u(c^o r, t+1) + \chi A_{r,t} - \psi B_{r,t} - \mu 1r \neq s, (1)$$

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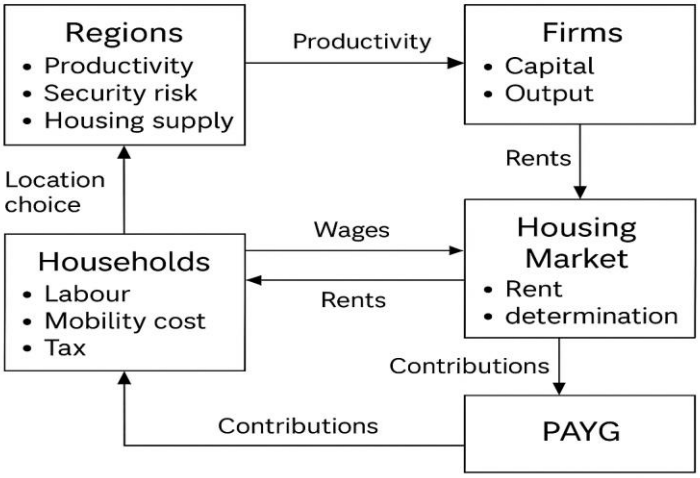

Fig. 1. Structural Diagram of the Dynamic Spatial OLG Model

where the amenity value of productivity and the disamenity of insecurity are captured by $\chi A_{r,t}$ and $\psi B_{r,t}$, respectively, the security-risk index $B_{r,t}$ is central to the structure: it not only enters utility directly but also reduces effective regional productivity and depresses the valuation of housing. Its effects are therefore transmitted simultaneously through labour income, housing costs and the non-pecuniary attractiveness of a region. When young, individuals face the budget constraint

$$c^y r, t + sr, t + R_{r,t} h + \mathrm{l}_{r,t} + 1r \neq sCsr = (1 - \tau_t) w_{r,t}, \quad (2)$$

while old-age consumption follows

$$c^o r, t + 1 = (1 + r^*) sr, t + b_{t+1}. \quad (3)$$

Location decisions arise from the maximisation of this lifetime utility and are increasing in wages and productivity, and decreasing in rents, risks and mobility costs. Under standard random utility assumptions, these location choices translate into smooth migration probabilities that depend continuously on the underlying fundamentals.

Regional production follows a Cobb–Douglas specification,

$$Y_{r,t} = A_{r,t} K_{r,t}^{\alpha} L_{r,t}^{1-\alpha}. \quad (4)$$

Security risk affects productivity according to

$$A_{r,t} = \bar{A} r e^{-\theta B B_{r,t}}, \quad (5)$$

so that unsafe regions experience both lower amenities and lower efficiency. Firms hire capital at an exogenous world interest rate and choose capital to satisfy

$$\alpha A_{r,t} K_{r,t}^{\alpha-1} L_{r,t}^{1-\alpha} = r^{+} \delta, \quad (6)$$

which implies a unique capital stock

$$K_{r,t} = \left(\frac{\alpha A_{r,t} L_{r,t}^{1-\alpha}}{r^{+} \delta} \right)^{1/(1-\alpha)}. \quad (7)$$

Differentiating this expression with respect to risk yields a strictly negative derivative, since regional productivity decreases with risk. Substituting this expression into the wage equation

$$w_{r,t} = (1 - \alpha) A_{r,t} K_{r,t}^{\alpha} L_{r,t}^{-\alpha} \quad (8)$$

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demonstrates that wages decline monotonically in regional risk as well. Both effects are essential: lower risk raises productivity directly and increases capital inflows indirectly, making regions safer not only in an amenity sense but also in economic terms.

The housing market provides an additional mechanism through which risk shapes equilibrium outcomes. Housing supply is fixed within each period, and rents adjust according to

$$R_{r,t} = \bar{R}r\left(\frac{hLr,t}{\bar{H}r,t}\right)^{\zeta} e^{-\xi BB_{r,t}}. \quad (9)$$

The term $e^{-\xi BB_{r,t}}$ captures the discount that households apply to housing services in insecure environments, while the labour-demand component reflects short-run inelasticity of supply. Differentiating this expression with respect to risk yields

$$\frac{\partial R_{r,t}}{\partial B_{r,t}} = R_{r,t}\left[\zeta \frac{1}{L_{r,t}}\frac{\partial L_{r,t}}{\partial B_{r,t}} - \xi_B\right], \quad (10)$$

which is strictly negative because both the direct discount term and the induced migration response $(\partial L_{r,t}/\partial B_{r,t})$ are negative. Hence, a risk reduction unambiguously raises equilibrium rents.

To establish how risk affects migration flows, consider the deterministic part of lifetime utility $(\widetilde{U_{sr,t}}(r))$. Its derivative with respect to risk is

$$\frac{\partial \widetilde{U_{sr,t}}(r)}{\partial B_{r,t}} = \frac{\partial u(c^{y}_{r,t})}{\partial w_{r,t}}\frac{\partial w_{r,t}}{\partial B_{r,t}} + \chi\frac{\partial A_{r,t}}{\partial B_{r,t}} - \psi, \quad (11)$$

where each term is negative, therefore $\widetilde{U_{sr,t}}(r)$ it is strictly decreasing in risk. Under a logit decision rule,

$$P_{sr,t} = \frac{exp\left(\gamma\widetilde{U_{sr,t}}(r)\right)}{\sum k\in\mathcal{R}\, exp\left(\gamma\widetilde{U_{sk,t}}(k)\right)}, \quad (12)$$

the derivative

$$\frac{\partial Psr,t}{\partial B_{r,t}} = \gamma P_{sr,t}\left(1 - P_{sr,t}\right)\frac{\partial\widetilde{U_{sr,t}}(r)}{\partial Br,t} \quad (13)$$

is strictly negative. A fall in risk, therefore, increases the probability that a young person chooses region (r), raising labour supply there and lowering it elsewhere.

The PAYG system links these regional adjustments to national fiscal dynamics. Total contributions equal $(\tau_t \sum_r w_{r,t}\, L_{r,t})$. Because wages and labour inflows both rise when risk falls, the derivative of this total contribution base with respect to $(B_{r,t})$ is negative. Under fixed benefits, the contribution rate must rise when risk increases; under fixed contribution rates, benefits adjust downward. In either case, the spatial distribution of risk has direct implications for intergenerational redistribution.

These intermediate derivations ensure the internal coherence of the model: lower risk raises productivity, wages and amenities; higher wages and amenities attract young workers; the inflow of workers tightens housing markets and increases rents; and changes in wages and labour supply shift the fiscal position of the PAYG system.

Because each component of the system responds monotonically to risk, the mapping from population distributions to wages, rents, and utilities, and back to population distributions, is continuous, and the space of possible distributions is compact and convex. This ensures the existence of a fixed point and thereby a dynamic spatial equilibrium.

The model therefore closes with a well-defined dynamic spatial equilibrium in which regional security, productivity, wages, housing-market tightness, mobility frictions, and intergenerational transfers jointly determine the long-run allocation of population and economic activity across space. Because security risk enters simultaneously as an amenity, a determinant of productivity and a discount factor in housing valuation, changes in the regional risk profile propagate through all markets in a mutually reinforcing manner. Lower risk improves effective productivity and raises wages; higher wages attract young workers; inflows of workers tighten local housing markets and increase rents; changes in the wage bill alter the fiscal position of the pay-as-you-go pension system; and shifts in the pension system feed back into disposable income and thereby into individual location decisions. With housing supply fixed in the short run and

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mobility imperfect, the economy does not eliminate spatial differences instantly; instead, it converges to an equilibrium in which safety-driven wage differentials and rent gradients coexist with persistent population patterns.

The equilibrium is thus characterised by a system of mutually consistent wages, rents, capital stocks, population distributions and fiscal variables, all of which resolve from the interplay of regional risk and individual spatial choices. This logical closure ensures that the theoretical framework is sufficiently rich to capture the principal mechanisms relevant for a conflict-affected economy, while remaining coherent, internally consistent and capable of generating clear predictions for empirical examination and policy design.

This spatial OLG simulation model provides a dynamic analytical framework for evaluating regionally differentiated public policies within an ageing economy. By incorporating endogenous migration, wages, rents, and PAYG burdens across heterogeneous territories, the model enables the ex ante assessment of how specific interventions, such as housing subsidies, infrastructure investment, or pension reform, reshape equilibrium trajectories over time.

The model supports an evidence-based policy design by visualising how alternative policy scenarios influence the spatial distribution of population and fiscal sustainability. It also helps identify which policy levers are most effective at mitigating demographic decline or fiscal stress in high-risk regions, thereby providing a robust empirical basis for targeted, regionally adaptive welfare interventions.

Conclusions and Directions for Further Research

This study has developed a dynamic spatial overlapping-generations model that links regional security, labour mobility, housing-market frictions and the PAYG pension system within a unified analytical framework. By treating security risk as a key spatial characteristic influencing amenities, productivity and housing valuation, the model demonstrates how improvements in regional safety trigger mutually reinforcing adjustments in wages, rents, migration flows and fiscal balances. Lower risk raises productivity and attracts young workers, while the resulting pressure on inelastic housing markets increases rents and indirectly shapes the financing of intergenerational transfers. The model thus provides a coherent explanation for the spatially uneven economic dynamics observed in conflict-affected settings.

Although the framework captures the main mechanisms relevant to post-conflict recovery, several extensions would enrich future research. Allowing housing supply to adjust endogenously would enable an analysis of reconstruction and urban redevelopment. Introducing heterogeneous households with different risk sensitivities or income profiles would refine the model's distributional implications. A further avenue involves embedding expectations about future security conditions to capture forward-looking relocation and investment decisions. Finally, calibration to regional Ukrainian data would allow the simulation of alternative recovery scenarios and provide a solid basis for policy evaluation. Together, these extensions would strengthen the model's ability to inform regionally sensitive and fiscally sustainable recovery strategies.

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ПРОСТОРОВА OLG-МОДЕЛЬ РЕГІОНАЛЬНОГО РИЗИКУ: ПРОДУКТИВНІСТЬ, МОБІЛЬНІСТЬ, ЖИТЛО ТА ПЕНСІЙНІ ТРАНСФЕРИ

Мета. Метою дослідження є розроблення узагальненої динамічної просторової теоретичної моделі, здатної відтворити взаємодію між регіональною безпекою, мобільністю робочої сили, жорсткістю житлового ринку та міжпоколінними фіскальними механізмами в умовах асиметричних шоків та воєнних загроз. Дослідження

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спрямоване на виявлення способів, якими просторові ризики здатні трансформувати поведінку економічних агентів, структуру ринку праці та довгострокову міжрегіональну рівновагу. **Методика.** Методичну основу становить динамічна просторово-економічна модель з перекриттям поколінь (OLG), у межах якої індивіди оптимізують вибір місця проживання, споживання, заощаджень та міграційних рішень. У моделі формалізовано вплив індексу регіонального ризику на продуктивність, заробітні плати, рентні ставки, локальну привабливість та параметри функціонування PAYG-пенсійної системи. Аналітичний апарат моделі містить проміжні доведення, що демонструють монотонний вплив ризику на ключові макроекономічні змінні, та визначає існування динамічної просторової рівноваги. **Результати.** Визначено аналітичну залежність регіонального ризику безпеки і встановлено характер впливу на ефективну продуктивність та заробітні плати, внутрішню міграцію молодого населення, тиск на обмежену пропозицію житла та формування стійких регіональних диференціалів ренти. Показано, що короткострокова нееластичність пропозиції на ринку житла посилює регіональні диспропорції й уповільнює вирівнювання економічних умов між територіями. Отримано аналітичний висновок, що зміни в розподілі зайнятості трансформують фіскальні параметри PAYG-системи, створюючи нові міжрегіональні дисбаланси. **Наукова новизна.** Уперше запропоновано інтегровану динамічну просторову модель, у якій показник безпеки одночасно виступає як якість середовища проживання, детермінантою продуктивності та фактором капіталізації на ринку житла. Така конструкція дає змогу ідентифікувати «мультиплікатор безпеки» як ключовий механізм поширення конфліктних шоків у просторовій економіці. **Практична значимість.** Результати дослідження можуть бути використані органами влади та аналітичними центрами для прогнозування післявоєнного відновлення, розроблення політики регіонального вирівнювання, оптимізації житлових та транспортних програм, а також оцінювання стійкості пенсійної системи в умовах демографічних і просторових зрушень.

Ключові слова: просторове моделювання; регіональна безпека; ризик; міграція; житловий ринок; продуктивність; PAYG; міжпоколінні трансфери

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