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Computable General Equilibrium Models for Migration Analysis: Bibliometric Approach[1]

Abstract. Computable general equilibrium (CGE) models are widely used to analyse the effects of migration on macroeconomic indicators in both origin and destination countries. Given the often-controversial results of this modelling approach, this paper seeks to systematize the existing experience in constructing CGE models for migration analysis. The methodology includes a bibliometric analysis incorporating complex humanitarian expertise. The analysis indicates that CGE models have gained prominence in assessing migration effects, with their application in high-ranking journals and a substantial number of citations. The literature review reveals that many migration models build on trade models that incorporate realistic assumptions about technological distribution across countries. Additionally, the geographic characteristics of regions play a key role in the diffusion of migration effects. Several studies highlight the significant economic impacts of migration. While migration is often associated with improvements in regional well-being in destination countries, emigration can lead to productivity declines in origin countries due to labour outflows. Furthermore, the effects on wages depend on the skill composition of migrants, with potential disparities between high-skilled and low-skilled workers. A promising avenue for future research lies in constructing CGE models tailored for developing countries, with a particular focus on social tensions and firm heterogeneity.

Keywords: general equilibrium model, labour market, migration costs, productivity, trade costs, internal migration, external migration

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ОБЗОРНАЯ СТАТЬЯ

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АНАЛИЗ МИГРАЦИИ С ПОМОЩЬЮ ВЫЧИСЛИМЫХ МОДЕЛЕЙ ОБЩЕГО РАВНОВЕСИЯ: БИБЛИОМЕТРИЧЕСКИЙ ПОДХОД

Аннотация. Вычислимые модели общего равновесия широко используются для анализа влияния миграции на макроэкономические показатели как в странах происхождения, так и в странах назначения. В свете противоречивых результатов, полученных в рамках модельного подхода в данной статье ставится задача систематизировать опыт построения CGE-моделей миграции. Методология исследования включает библиометрический анализ с комплексной гуманитарной экспертизой. В последние годы CGE-модели стали популярным инструментом в изучении последствий миграции. Исследования, использующие этот подход, хорошо представлены в престижных журналах и имеют высокий уровень цитируемости. Обзор литературы показывает, что многие модели миграции основаны на моделях торговли, которые включают реалистичные предположения о распределении технологий между странами. Географические особенности населенных пунктов также играют решающую роль в распространении эффектов миграции. В то время как в странах назначения часто фиксируется связь между миграцией и улучшением благосостояния в регионах, в странах происхождения эмиграция может привести к снижению производительности из-за оттока рабочей силы. В целом, в странах с положительной чистой миграцией снижение миграционных барьеров приводит к повышению производительности труда и благосостояния граждан. Влияние миграции на уровень зарплат может зависеть и от доли высококвалифицированных и низкоквалифицированных мигрантов. Перспективным направлением дальнейших исследований является построение CGE-моделей для развивающихся стран, учитывающих такие параметры, как уровень социальной напряженности и гетерогенность фирм.

Ключевые слова: модель общего равновесия, рынок труда, издержки миграции, производительность, издержки торговли, внутренняя миграция, внешняя миграция

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Introduction

Migration, both internal and international, is a significant subject of scholarly inquiry across various disciplines, including economics, sociology, and political science. As populations shift and societies evolve, understanding the determinants and consequences of migration remains essential. There are many factors that encourage people to migrate, including changes in migration policies of origin and destination countries or shifts in trade conditions between them. However, in general, access to attractive amenities, better employment opportunities, and improved living conditions are the primary drivers of these processes (Desmet et al., 2018).

Migration brings to destination economies both advantages and challenges (Ma, Tang, 2020). While immigration can expand the labor supply and stimulate entrepreneurship, it may also increase job competition and drive up housing costs for the host country's residents.

The same applies to countries of origin. Residents may experience a loss in welfare due to demographic changes, as the relocation of the economically active young population can negatively impact contributions to pension funds. Moreover, these countries may experience the loss of high-skilled labour, commonly referred to as brain drain (Marchiori et al., 2013).

The issue of migration is extensively examined in economic literature. Often, migration is studied along with labour productivity (Tombe, Zhu, 2019; Bryan, Morten, 2019). Some migration models are trade-based, recognizing trade as a crucial factor influencing migration patterns. There are also studies that use geographical features to analyse the dynamics of migration both between and within countries (Desmet et al., 2017; Desmet et al., 2018; Caliendo et al., 2019).

Different models are used to identify certain effects of emigration and immigration. In this paper the focus is made on publications that

use computable general equilibrium models for two reasons. First, these models are convenient for calculating the impact of different policy outcomes on migration and they can be a useful tool for studying migration processes. In this regard, it becomes important to understand how widely these models are used to analyse migration. Secondly, CGE models are characterized by large variations in assumptions about people's incentives to migrate. Consequently, different models may show differences in the impact of migration on productivity and well-being of migrants and natives. Other approaches to modelling migration include agent-based models, which have gained widespread popularity in Russian literature (Makarov et al., 2017; Makarov et al., 2019; Makarov et al., 2022), partial equilibrium models (see, for example, for the US and Mexico (Hanson, 2006)), as well as DSGE models (House et al., 2018; Hauser, Seneca, 2022).

This paper aims to provide a comprehensive review of the literature on migration using CGE approach. Current research will delve into the specific details of the models, including their assumptions and limitations. This approach will provide a more in-depth understanding of the topic and contribute to the existing body of knowledge on migration.

The paper is structured as follows. The second section presents statistics on international migration by world regions over recent years. The third section provides a comprehensive bibliometric analysis of the migration literature incorporating CGE. The fourth section reviews how migration and trade decisions are modelled within CGE frameworks. The fifth section examines migration models with heterogeneous firms under both perfect and monopolistic competition in trade. The sixth section analyses general equilibrium models that account for worker skills. Finally, the paper concludes with a summary of key findings.

Overview of migration processes

Given the unique circumstances facing Russia, labor migration remains a critical economic concern. In 2022, migration activity surged, driven largely by the withdrawal of international businesses and the resulting employee relocations, as well as significantly increased trade barriers with developed economies. At the same time, the government pursued policies aimed at simplifying the citizenship acquisition process for foreigners, effectively reducing migration costs. However, for certain categories of migrants, obtaining citizenship has become more challenging. More broadly, the issue of large-scale emigration and immigration flows is not unique to Russia.

According to UN statistics, migration remains a highly pressing global issue. Unsurprisingly, Asia, Europe, and North America, which host the majority of international migrants, also attract significant scholarly attention. Key origin and destination regions, such as the United States, the European Union, Russia (Sushkov, 2018), and China with its internal migration, receive significant academic attention, with a large body of literature addressing migration issues in these areas.

Figure 1 illustrates migration stocks by origin and destination. It shows little change in the

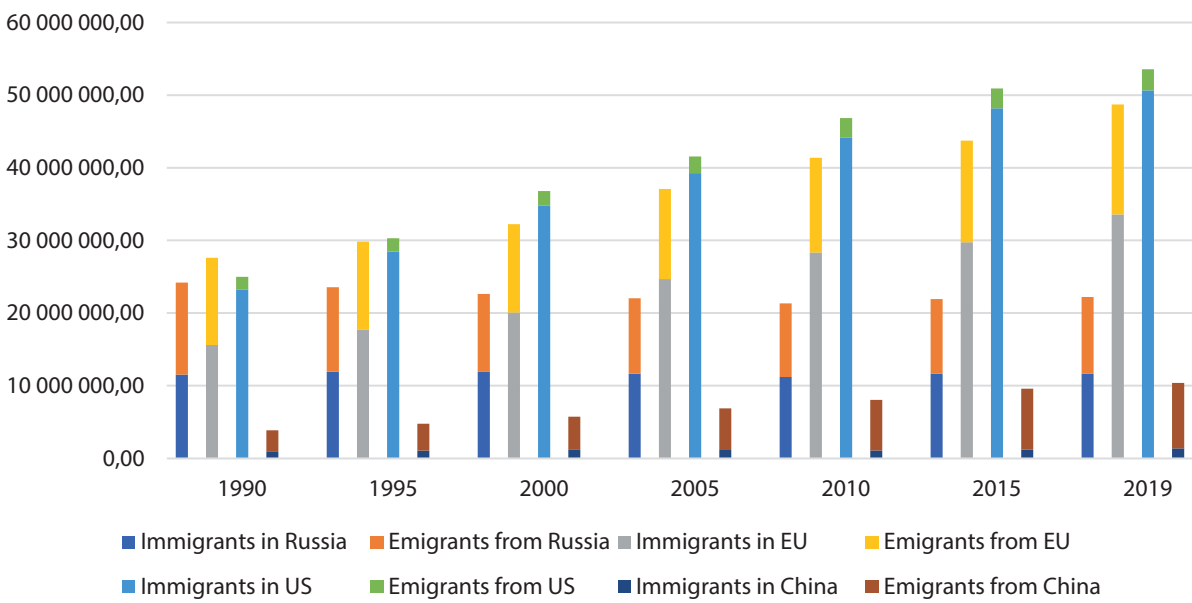

Figure 1. *Migration between regions of the world. Source: Compiled by the author based on UN data*

number of immigrants in Russia from 1990 to 2019, with a noticeable decline between 1995 and 2010, followed by an increase in immigration. In contrast, emigration from Russia presents a more concerning trend. While the number of emigrants had been decreasing since 1990, a significant shift occurred in 2010, interrupting the downward trend and marking the beginning of a gradual rise in the number of Russian citizens living abroad. It is important to note that for Russia, the study of internal migration is also significant, as the share of foreign migrants in Russia is relatively small (Bondarenko, 2022).

According to Serebrennikova et al. (2016) and Mkrtchyan & Florinskaya (2018), Russia's migration process is marked by brain drain, which means that emigrants tend to be more highly educated than the national average, while immigrants to Russia are generally less educated. The country, therefore, faces two main challenges: integrating immigrants into society and losing highly qualified personnel.

Figure 1 shows a significant increase in immigrants to the European Union and the United States over the past 30 years, while emigration from these countries has remained low. This rapid rise in immigration has a downside, often leading to social tensions. Some researchers link this trend to ineffective migration policies (Castles, 2019) and describe the situation as a migration crisis (Buonanno, 2017). According to Hollifield et al. (2014) and Scipioni (2018), EU migration policy is particularly prone to failure, allowing illegal migrants to enter and move freely between member states. However, the EU's current migration policy primarily focuses on selecting migrants based on skills and origin (De Haas, 2019), while stressing the importance of integrating them into society (Van Mol, De Valk, 2016; Doomernik, Bruquetas-Callejo, 2016).

In China, migration patterns involving emigration and immigration are less prominent compared to the other countries discussed. Figure 1 shows that both immigration to China and emigration from China are the lowest among the countries listed. Internal migration, particularly from rural to urban areas, is more significant (Chan, 2013), and research on migration in China mainly focuses on this internal movement (Chan, 2012; Garriga et al., 2023). Thus, migration remains a relevant issue in all these countries, each facing distinct challenges.

Data and Methods

One of the tools for analysing migration is general equilibrium models. They allow to simulate various scenarios of the impact of certain changes in government policy on the economic indicators of countries and regions. A comprehensive bibliometric analysis of the literature can be conducted to determine whether general equilibrium models satisfy the requirements of modern macroeconomic research, to evaluate the extent of their application in migration studies, and to identify the implications of mass migration for origin and destination countries.

Using the methodology outlined by Dzyuba and Bakalova (2022), this study analyses data on publications related to CGE topics from 2000 to 2022. Google Scholar and Scimago Journal & Country Rank services are the primary tools. The first step highlights publications focused on migration modelling with the general equilibrium approach. This is done through an advanced keyword search in Google Scholar, which allows specifying required words and phrases that must appear in the articles. Google Scholar also searches for articles containing at least one of the specified terms. Although the exclusion field can filter out certain terms, this option is not used in this study.

To search for articles on migration, it was decided to use the following terms that must appear in publications: "migration", "general equilibrium model", "migration costs", and "general equilibrium". It was decided to include the phrase "migration costs" to highlight those articles that are devoted to the migration topic. The reason is that Google Scholar detects all articles in which the keyword is mentioned at least once, and the phrase "migration costs" will accurately identify articles whose main topic is migration. A search for the single word "migration" does not exclude articles on related topics. In addition, it was decided to include the following words and phrases, at least one of which should appear in the article: "mobility frictions", "international migration", "external migration", "internal migration", "economic geography", "migration policy". All these terms are not necessarily found in articles on migration with general equilibrium models, but at least one of them is often used in studies. The search in the selected database was carried out in all categories of publications — articles, review articles, books, and working papers, and in all sections of the articles.

The resulting sample consists of 671 publications with different number of citations. 25 publications from this list are review articles. Among the remainder, there are both papers from Q1 quartile journals and papers without any citations. Therefore, it was decided to analyse the compiled list of sources. In general, an analysis was

conducted on English-language articles, books, preprints, and all works that included translation of keywords, abstract, and title into English. It was found that the journals with the highest number of articles on the topic of migration utilizing the CGE approach are "Regional Science and Urban Economics" (8 articles, Q1), "Economic Modelling" (7 articles, Q2), "Journal of Development Economics" (6 articles, Q1), and "Journal of Population Economics" (6 articles, Q1).

Figure 2 shows the number of publications on migration using general equilibrium models from 2000 to 2022. The data reveal a gradual increase in the number of articles over time. Notably, annual publications surged in recent years, with more than 50 articles per year between 2020 and 2022, compared to fewer than 10 per year at the start of the analysed period.

Figure 2 also presents the relative number of articles on the migration topic. To highlight all articles related to migration with economic analysis, it was decided to use the following terms: "migration costs" and "economics." From 2000 to 2022, a total of 9,341 articles, books, and other materials on this topic were published. In this period, the share of articles employing general equilibrium models accounted for approximately 5–10 % of the total number of articles on migration, with a significant decline observed in 2007. It is worth noting that in recent years, there has been an increase in the relative number of articles utilizing the CGE approach.

However, the number of articles alone does not indicate the quality of migration research. To better understand the academic importance of the field, it is crucial to look at other factors, such as citation counts and publications in high-impact journals.

Figure 3 illustrates the number of citations for journals focusing on migration and involving the use of general equilibrium models. The data reveal a substantial overall number of citations for publications in this area. A positive correlation is observed between the number of published articles and the annual citation count. Notably, the highest numbers of citations are associated with articles from 2006, 2011, and 2019. The most cited works on migration are papers that explore migration modelling, as well as books about migration. For example, the paper by Anderson (2011) titled "The Gravity Model" has been cited 2,094 times and presents a gravity model that takes migration into account. The book by Borjas (2014) titled "Immigration Economics" has 715 citations and covers various topics related to migration. The same applies to the book edited by Mansoor et al. (2006), "Migration and Remittances: Eastern Europe and the Former Soviet Union", which presents a general equilibrium model and has 601 citations. Another highly cited work is written by Caliendo, Dvorkin and Parro (2019) titled "Trade and Labor Market Dynamics: General Equilibrium Analysis of the China Trade Shock".

Let's examine the number of citations on the migration topic over the last five years. However, relying solely on citation metrics may not accurately reflect research quality, as the limited time since publication can result in fewer citations for high-quality papers that have not yet been referenced by subsequent studies.

An alternative graph presents the number of articles published in journals across five rating

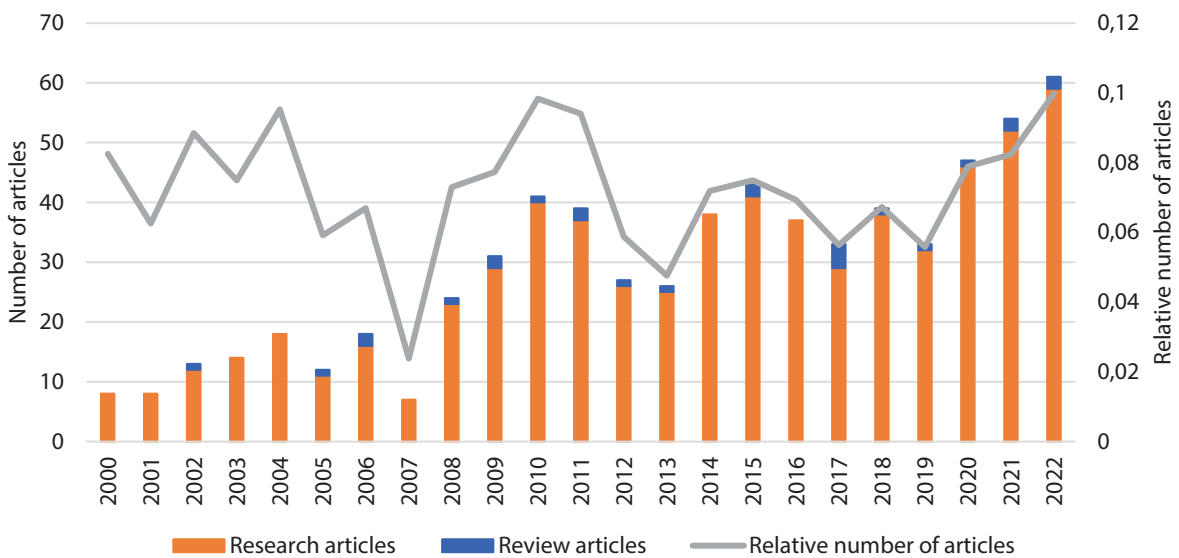

Figure 2. *Number of publications on migration employing the CGE approach.*
Source: Compiled by the author on the basis of data from Google Scholar

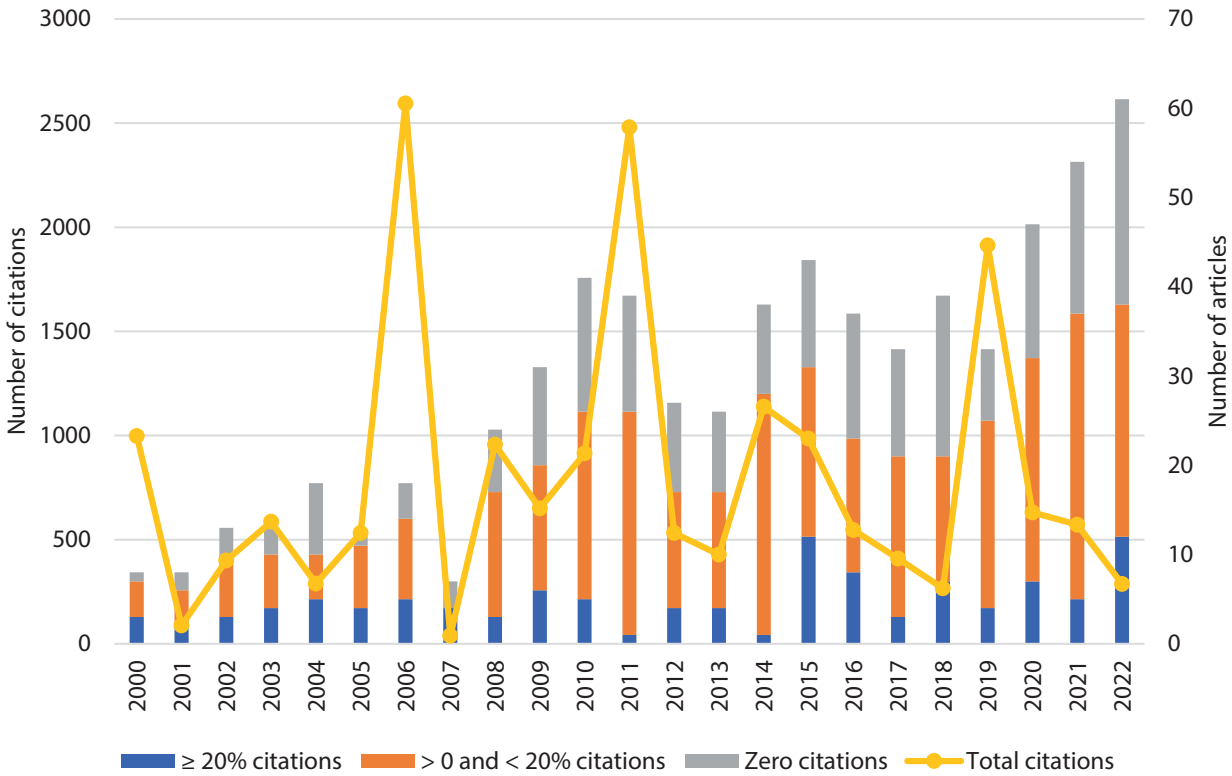

Figure 3. *Number of journal citations on migration employing the CGE approach. Source: Compiled by the author on the basis of data from Google Scholar*

categories from 2018 to 2022: "Other," "Q1," "Q2," "Q3," and "Q4." The "Other" category includes publications without a Scimago ranking but with at least one citation.

Figure 4 provides compelling evidence regarding the scholarly activity in migration research. A large segment of publications consists of working papers and books without a formal scientific rating. Moreover, a significant share of articles appears in leading (Q1) journals, along with a substantial presence in Q2 publications. This finding strongly suggests that a considerable amount of research, utilizing general equilibrium models, has been dedicated to understanding migration in the last five years. This trend underscores the growing recognition of migration as a critical area of study and reinforces the importance of general equilibrium models in its analysis.

Due to search limitations, some articles in this dataset may not fully align with the criteria outlined, yet they still demonstrate the keen attention of researchers worldwide towards migration topics.

The CGE approach is gaining popularity in migration studies and frequently appears in prestigious journals.

Further analysis requires a deeper literature review to identify which countries benefit from migration, the reasons behind it, and who bears the costs, while also uncovering key channels through which migration impacts economies. To achieve this, it was decided to examine the most cited articles using the CGE approach in migration modelling, identified additional studies referenced within them, and categorized the research domains.

Modelling Migration and Trade in General Equilibrium

The quantitative Ricardian model developed by Eaton and Kortum (2002) is one of the standard trade models used, among other things, to analyse the consequences of migration, subject to some modifications.

The main reason is that one of the most important transmission channels for migration effects is trade. According to Rapoport (2018), diaspora affects trade between countries, foreign direct investment, the spread of technology and social norms. Communication becomes more accessible as a result of the diffusion of language and culture. In addition, immigrants can help establish business relationships with their country of origin, as well as provide valuable information about overseas sales and make sourcing more accessible.

As Costinot and Rodríguez-Clare (2014) noted, the Eaton and Kortum (2002) model is a trade model based on the gravity equation, differing

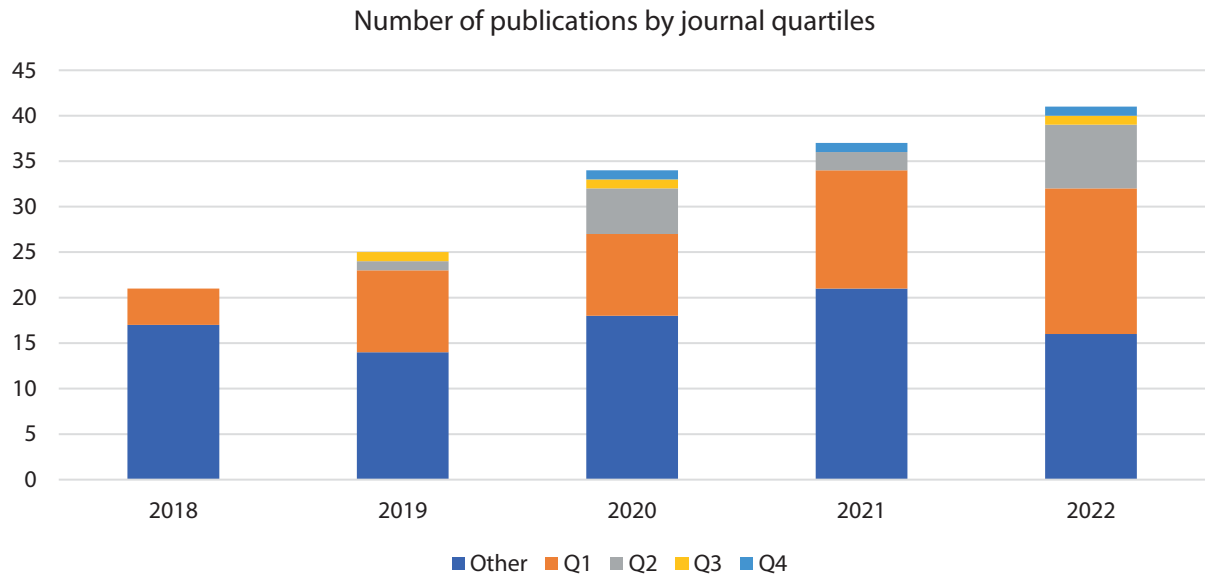

Figure 4. *Number of publications on migration employing the CGE approach by journal quartiles. Source: Compiled by the author on the basis of data from Google Scholar and Scimago Journal & Country Rank*

from others in assuming firms operate under perfect competition. In contrast, Melitz (2003) introduces monopolistic competition with firm-level heterogeneity. While both models assume that bilateral trade flows depend on macro-level bilateral costs, the key difference is that monopolistic competition leads to a greater impact of trade on income than perfect competition.

To assess the effects of migration on the economy, Desmet et al. (2018) add the trade structure from Eaton and Kortum (2002) to their migration model. They use the idea that the share of goods purchased in one location from another is equal to the share of spending on goods from the second location. Tombe and Zhu (2019) add the possibility of domestic trade and labour mobility to the Eaton and Kortum (2002) model. They model destination choice in terms of migration costs and heterogeneous worker preferences for locations and sectors. Caliendo et al. (2019), Bryan and Morten (2019) rely on Eaton and Kortum (2002) model to describe talent distributions, employee preferences, and productivity. They assume that these characteristics have a Fréchet distribution.

Now we can take a closer look at the trade model, a simplified version of which is described by Dhingra et al. (2017). As already mentioned, the firms operate under perfect competition. International trade in this model depends on trade barriers and geographical distance between regions. Also, the efficiency levels differ across commodities and countries due to varying access to technology in different regions. For ease of analysis, Dhingra et al. (2017) consider a one-sector model with final goods and no tariff revenues.

Researchers consider N countries indexed by $n = 1,\ldots, N$. All countries trade with each other. Each country has L_n identical households that inelastically supply one unit of labour at salary w_n. Welfare in the model is measured in terms of real consumption:

$$c_n = \frac{z_n}{P_n}, \quad (1)$$

where z_n is household spending and P_n is the country's price index. The latter is calculated for a basket of goods imported into or produced in a country. In particular, the weight of each country in country n's basket of goods depends on how accessible that country is in terms of geographic features and trade barriers.

As Eaton and Kortum (2002) mention, the expression for the price index shows the importance of geographical barriers. Therefore, it is possible to generate different price levels in different countries. For each country, the price index is calculated as the geometric mean of the prices of all goods that are delivered:

$$P_n = \gamma(\Phi_n)^{-\frac{1}{\theta}}, \quad (2)$$

where γ is a constant term and Φ_n is a price parameter. The latter covers state of technology T_i, input costs w_i and geographic barriers in the form of trade obstacles d_{ni}:

$$\Phi_n = \sum_{i=1}^{N} T_i \left(w_i d_{ni}\right)^{-\theta} \quad (3)$$

International trade plays a crucial role in enhancing the technological capabilities of each country by providing access to technology from other countries. This is an important assumption for migration modelling. Desmet et al. (2018) state that firms benefit from the diffusion of innovations, while Ma and Tang (2020) highlight the importance of firms for migration.

The fraction of goods that country *n* buys from country *i* is as follows:

$$\lambda_{ni} = \frac{T_i \left(w_i d_{ni}\right)^{-\theta}}{\Phi_n} \quad (4)$$

Since markets are perfectly competitive and profits are zero, household expenditures are equal to labour income. Prices for all goods are set at the level of the marginal cost of delivering one unit of goods to its destination area. Additionally, expenditures do not vary by source and the fraction of goods λ_{ni} represents the amount spent on goods from country *i*.

This brings us to the gravity equation:

$$X_{ni} = \frac{T_i \left(w_i d_{ni}\right)^{-\theta}}{\Phi_n} X_n, \quad (5)$$

where θ is the elasticity of bilateral exports with respect to bilateral barriers, X_{ni} is country *n*'s spending on goods from *i* and X_n is total spending. This equation describes exports from country *i* to country *n*, considering the characteristics of the importer, exporter, and bilateral trade barriers. This ratio shows that bilateral exports are facilitated by a higher level of technology in the exporter and a higher level of income in the importer. Negative effects include higher wages, closer relationships between the importer and trading partners, which allows for choice among goods providers, and higher barriers to trade.

Equilibrium in this model is determined using the aggregate budget constraints of all countries. These restrictions ensure that for all pairs of countries, bilateral trade is balanced and the condition that the income of country *n* is equal to the expenditures of all countries including country *n* on goods produced by country *n*. Therefore, there are *N* non-linear equations with *N* unknown wages. The non-linearity arises because Φ_{ni} and Φ_i are non-linear wage functions. In this case, the system cannot be solved analytically, so Dhingra et al. (2017) suggest using numerical methods to calculate equilibrium wages.

Thus, it is possible to calculate the real consumption of households, or a measure of well-being, as:

$$c_n = \frac{w_n}{\gamma \left(\Phi_n\right)^{-\frac{1}{\theta}}} \quad (6)$$

Considering that labour is the only source of income in this simplified model, the written metric coincides with the real income of households. A well-being metric like this is then often used in migration models to analyse migrant performance.

Authors studying migration's effects rely on existing trade patterns, which models must refine to account for migration. While these models realistically depict trade relations, their assumptions—such as perfect or monopolistic competition—are controversial, with differing opinions in the scientific community on the better approach.

It is also important to explain how different papers model the migration process. A common approach in CGE literature is to describe the fraction of the population migrating from region *i* to region *j*:

$$m_i^j = \frac{\left(V_i / \mu_i^j\right)^{\kappa}}{\sum_{i'=1}^{N} \left(V_{i'} / \mu_{i'}^j\right)^{\kappa}} \quad (7)$$

where V_i is the real wages in each region, μ^j_i are migration costs, κ is the degree of dispersion across individuals which may be estimated empirically and *N* is the number of locations. This example is from the paper by Tombe and Zhou (2019). Equation (7) summarizes the desirability of locations and can be modified to include different characteristics. For instance, Desmet et al. (2018) incorporate utility from consumption and amenities, Brayan and Morten (2019) include relative returns, and Caliendo et al. (2019) use a model with lifetime utility. Other approaches to describing migration in CGE models are also available (e.g., Marchiori et al., 2013; Ma, Tang, 2020; Nesterova, 2021).

Migration Models with Heterogeneous Firms and Trade

Migration can be either external or internal. However, in general equilibrium models, researchers typically focus on one type at a time to simplify the analysis, often restricting the study to either external or internal migration based on their objectives.

Many studies on internal migration focus on China (Tombe, Zhu, 2019; Ma, Tang, 2020; Hao et al., 2020; Yang et al., 2020), driven by significant shifts in migration patterns over recent decades due to domestic policies that have also affected interprovincial trade (Hao et al., 2020).

Understanding China's migration experience requires a brief look at its economic history. In 1958, the Chinese government introduced the hukou system, a household registration policy that assigned rural or urban status to each resident, making population mobility difficult to control.

From 1958 to 1978, people in China were prohibited from working outside their registered place of residence. After 1978, some restrictions eased, but a temporary residence permit was still required to work in a different administrative unit. It wasn't until 2003 that the migration process was significantly simplified, with some provinces completely removing internal migration requirements.

According to Chan (2010), up to 800 million rural residents in China had limited access to social benefits that were freely available to urban residents due to the hukou system. At the same time, rural residents who worked in cities were typically paid significantly lower wages.

To examine the impact of infrastructural changes and the liberalization of migration policy on productivity shifts, Tombe and Zhu (2019) developed a multi-regional general equilibrium model incorporating two sectors—domestic and international trade—and internal migration. The authors used the Eaton and Kortum (2002) model to represent interregional trade and labour mobility, capturing the relationship between trading partners. In this model, migration is influenced by both migration costs and individuals' heterogeneous preferences regarding sectors and regions. Additionally, the authors account for institutional features of the country, such as collective land ownership, which may limit migration opportunities.

The analysis highlights several positive outcomes of migration. Lower migration costs encourage greater population movement, with individuals migrating toward higher-income regions. These migration flows contribute to improved macroeconomic performance, reflected in higher GDP per capita and increased worker well-being. Furthermore, migration reduces interprovincial income inequality by moderating real incomes in destination areas, with an overall boost in worker productivity.

The reduction in trade costs, in turn, leads to a reduction in internal migration. One possible explanation is that the prices of goods in poor regions are declining. The corresponding increase in the real income means that fewer workers are willing to migrate. The same study indicates an increase in the number of people who migrate from one sector to another within the region.

Bryan and Morten (2019) analyse the relationship between migration and labour productivity in their study on Indonesia, focusing on the impact of reducing migration barriers. Similar to the study by Tombe and Zhu (2019) discussed above, the authors use microdata for their calculations. However, Bryan and Morten place greater emphasis on migration costs.

The authors highlight the importance of considering both moving costs and differences in amenities. The former suggests that individuals will migrate only if they expect higher wages in their destination regions, while the latter implies that certain locations must offer higher wages to attract labour.

This analysis is driven by the idea that migration can enhance productivity by enabling individuals to relocate to areas where they can be more productive—a process the authors refer to as sorting. Another mechanism, which Bryan and Morten (2019) describe as agglomeration, occurs when migration increases the number of people living in a more productive location.

To account for both effects, the researchers construct a model in which individuals have idiosyncratic productivity level depending on their locations. Additionally, the model incorporates two types of mobility restrictions — movement costs and compensating wage differentials. Movement costs represent the wage premium required to incentivize workers to relocate, while compensating wage differentials emerge when individuals accept lower wages to move to areas with fewer amenities, reflecting a trade-off between income and quality of life.

Bryan and Morten (2019) also construct their model on the trade model developed by Eaton and Kortum (2002). In their framework, workers born in a particular location, acquire skills for each of the possible destinations, and are sorted into destination locations according to three factors: wages, amenities, and migration costs. The first two characteristics are determined endogenously, while migration costs depend on the place of origin.

The findings show that eliminating mobility costs increases productivity by 7.5 %. However, productivity may also decline as mobility costs drop, possibly because individuals leave high-productivity, low-amenity regions for lower-productivity areas with better amenities.

Caliendo et al. (2019) use the Eaton and Kortum (2002) trade model to develop a dynamic spatial model incorporating trade and migration, assuming heterogeneous firms produce intermediate goods. Their study focuses on the impact of trade shocks on the U.S. labour

market, highlighting that China's exports to the U.S. doubled from 2000 to 2007, coinciding with a decline in U.S. manufacturing jobs and growth in services and construction. Prior research links increased trade to employment shifts (Autor et al., 2013; Acemoglu et al., 2016), with Acemoglu et al. (2016) estimating 2–2.4 million U.S. job losses due to rising Chinese imports.

Caliendo et al. (2019) examine how China's productivity shifts affect U.S. employment across states and sectors. Their model, covering 38 countries, 50 states, and 22 sectors, incorporates trade and labour market dynamics while restricting external migration for simplicity. They find that rising competition from China led to a loss of 0.55 million U.S. manufacturing jobs (16 % of total losses from 2000–2007) but added 50,000 construction jobs due to cheaper intermediate goods from Chinese exports. While trade shocks affect sectors differently, overall U.S. well-being improves from trade with China.

Chakrabarti and Sengupta (2017) analyze internal migration in the U.S. using gravity equations, similar to those in trade models (Eaton & Kortum, 2002). They find that productivity shocks explain up to 63 % of interstate migration.

Ma and Tang (2020) highlight a key limitation of the Eaton and Kortum (2002) model—its inability to account for firm entry and exit. They suggest that Tombe and Zhu (2019) observed a negative impact on real wages due to this rigidity, which occurs when the number of firms remains constant.

Ma and Tang (2020) examine how immigration affects local economies and state migration policies, noting that large inflows can create political tensions if they negatively impact city residents despite national benefits.

Using a general equilibrium model based on Melitz (2003) and Eaton et al. (2011), they improve on Eaton and Kortum (2002) by incorporating firm heterogeneity. Their model allows individuals to choose locations based on wages, congestion, migration costs, and personal preferences. Migration can lower wages and increase congestion but also reduces prices and fosters business growth.

Focusing on China, they analyse migration at the city level and estimate geographic friction using data on roads, railways, and waterways. Their findings show that migration boosts urban economies by lowering wages, increasing demand, and encouraging firm entry, which expands product variety and improves well-being.

Ma and Tang (2020) also explore the relationship between migration and trade liberalization, finding mixed effects. Migration reduces domestic trade as consumers move closer to production centres, while trade liberalization benefits small towns and lowers migration incentives. Although some small towns may experience losses due to emigration, their overall analysis suggests that relaxing internal migration rules benefits the country as a whole.

Di Giovanni et al. (2015) apply the Melitz (2003) trade model to migration, highlighting its ability to capture key macro – and microeconomic dynamics. In their framework, migration expands market size, increasing the variety of goods available for consumption. While immigration benefits residents in the long run, short-term effects are more limited. For origin countries, the impact is mixed—generally negative, though some, like El Salvador, benefit due to remittances.

Desmet et al. (2018) further examine migration liberalization, focusing on international migration and incorporating detailed geographic data to assess trade and mobility costs. They emphasize the importance of location, noting that regional trade costs, amenities, and productivity levels shape migration patterns. Their model accounts for institutional constraints, social norms, and evolving regional conditions, including infrastructure, institutions, and technological development.

Desmet et al. (2018) also consider firms' incentives to invest in technology, influenced by market size and transportation costs. Technological advancements can spread across regions rather than solely emerging from direct investment. Lastly, population density has both positive effects, through agglomeration, and negative effects, through congestion costs.

To implement all these features within a single model, Desmet et al. (2018) divide the world map into $1° \times 1°$ cells. Each cell contains firms that produce goods using land and labour. Firms use technologies specific to location. They can also invest in technology improvements as in the Desmet and Rossi-Hansberg (2014) model. In this case, technological innovation depends on the market size in each location, which depends on the transportation costs and the overall spatial distribution of expenditure. At the same time, technologies do not remain constant forever but spread to neighbouring regions over time.

Desmet et al. (2018) find that migration liberalization significantly boosts output and welfare. Removing all mobility restrictions increases cross-border migration from 0.3 % to 70.3 % per year. Their model shows that, over time, the correlation between GDP per capita and population density becomes increasingly positive, indicating that people tend to migrate to more productive regions. As a result, high-density areas attract more investment, reinforcing their

productivity, which aligns with Ma and Tang's (2020) finding that firm emergence is concentrated in densely populated regions.

Thus, strict migration policies keep people in their home countries, ultimately benefiting nations that already have high population density.

This conclusion seems ambiguous since the lack of migration from less productive regions should also limit the development of origin countries. For instance, the brain drain phenomenon will not encourage the spread of technology through diasporas (Marchiori et al., 2013). One possible explanation is that in a world without migration, there may be no restrictions on the diffusion of technologies. These restrictions can be imposed in the form of sanctions both on countries and on individual firms, which will limit the technological development in certain regions. Additionally, Desmet et al. (2018) do not consider the qualifications of migrants, which could impact the study's findings. Another problem may lie behind data aggregation. Dividing the world into $1° \times 1°$ cells may result in a significant loss of information.

In their study on Asia, Desmet et al. (2017) emphasize that spatial frictions, such as trade costs and migration restrictions, shape long-term development. They find that lowering trade costs increases real income, while reducing migration costs also has a positive effect—though the extent varies depending on the type of reduction.

A counterintuitive finding is that lowering migration costs in Asia reduces real income per capita both globally and within the region, which happens because relaxed migration rules not only allow more entry from outside but also facilitate movement within Asia. As a result, more people relocate to less technologically developed areas like Mongolia and Tibet, where productivity gains fail to offset income declines in initially more developed regions.

Migration Models with Skills of Workers

In addition to the role of trade in migration, much of the literature emphasizes worker qualifications. Many studies, such as those by Marchiori et al. (2013) and Nesterova (2021), use overlapping generations models to explore the impacts of brain drain.

Nesterova (2021) develops a general equilibrium model with 100 overlapping generations across 165 countries in 17 regions. She examines various regional development scenarios and finds that, when migration is restricted, regions receiving net inflows of migrants experience a decline in GDP, with regions actively attracting immigrants facing the largest losses. Conversely, regions losing migrants see GDP growth. In this model, migration restrictions are represented by reducing the population of countries based on UN forecasts of net migration, considering skills and age distribution.

Nesterova (2021) classifies migrants as highly skilled or low-skilled. Her study shows that the arrival of low-skilled workers benefits the Russian economy, boosting GDP by 2.5 % compared to the baseline scenario. This influx stabilizes factor prices. She acknowledges limitations in her model, noting that the optimal factor ratio in some regions may differ from assumptions and that classifying people based on education data can be imprecise.

Marchiori et al. (2013) also explore the brain drain, emphasizing the challenges it poses for developed countries, such as increasing the burden on working-age residents who contribute to pension funds and causing a short-term decline in human capital. However, the outflow of highly skilled workers can benefit technologically less developed countries through their diasporas, which can boost human capital and spread technology.

To quantitatively analyse migration's economic impact, Marchiori et al. (2013) develop a general equilibrium model with 8 overlapping generations and 10 regions, using GDP per capita as a measure of migration's effect. In their model, emigration is an exogenous factor, not a personal choice.

The authors examine four channels of brain drain: demographic changes, human capital, technological progress, and risk premiums. They note that developing countries lose out demographically, as emigrants tend to be younger. The loss of highly skilled workers negatively impacts GDP per capita through the human capital channel. However, the threat of emigration can encourage more investment in education, boosting human capital in the long term.

Migration also has mixed effects through the technological progress channel. While skilled diasporas can promote technology transfer, the home country loses workers who could contribute to these advancements. The risk premium channel, however, positively impacts the economy, as a growing diaspora reduces information gaps and attracts more investment.

Despite these insights, the authors make unrealistic assumptions in their analysis, such as a 20 % increase in skilled migration every decade from 2010 to 2060, focusing only on young migrants aged 15 to 24. Their findings suggest that the cumulative demographic shock generally leads to a positive effect on per capita GDP in most regions, though sub-Saharan Africa and Latin America experience negative impacts.

Docquier et al. (2019) examine the impact of migration, population aging, and education on wages, highlighting how migration affects labour markets in both destination and origin countries. They emphasize that migrants and local workers are not perfect substitutes in productivity (Ottaviano & Peri, 2012; Manacorda et al., 2012), as factors like language proficiency and human capital influence migrants' labour market entry. Consequently, migration's impact depends on the age, education, and substitutability of migrants with local workers.

Unlike other studies, Docquier et al. (2019) use a CES production function with multiple nested categories, classifying workers into eight types. The first distinction separates highly skilled and low-skilled labour, followed by divisions into young and old workers, migrants and locals, and, finally, birthplace. However, this classification has limitations, as migrants from diverse backgrounds may fall into the same category, given that skill-level distinctions do not fully capture educational differences.

The findings reveal a nuanced relationship between migration and wages. Increased immigration tends to lower wages for highly skilled workers, indicating greater competition in that labour market segment. Conversely, low-skilled workers may experience wage gains, particularly in countries that attract a high share of highly skilled migrants. Emigration, on the other hand, benefits highly skilled workers who remain but exerts downward pressure on the wages of low-skilled workers.

In the study by Cardoso (2020) a nested CES framework is employed similarly to the approach taken by Docquier et al (2019). This research focuses on the EU member states, Brexit, and Turkey. The model posits that a country's exit from the EU increases the costs associated with migration, while accession to the EU reduces these costs for movement within its borders. Consequently, Brexit results in a decline in migration between the United Kingdom and the European Union, with a particularly pronounced impact on low-skilled labour in the UK, which decreases by 58 %, compared to a 49 % reduction in the number of high-skilled emigrants.

Biavaschi et al. (2020) examine skilled labour migration, emphasizing that higher-skilled individuals are more likely to emigrate. This raises the question of whether migrant skill composition affects residents' welfare.

To assess migration's economic impact, the authors develop a multi-country general equilibrium model incorporating trade, human capital externalities, and remittances. Their approach builds on Krugman's (1980) model, featuring two sectors and monopolistic competition in manufacturing. They classify labour into three skill levels—low, medium, and high—while recognizing that migrants and residents within each category are not perfect substitutes in destination countries. Unlike the Melitz (2003) model, they abstract from firm heterogeneity within sectors.

A key scenario explored is how trade expands as immigrants increase demand for goods from their home country and reduce trade costs (Felbermayr & Toubal, 2012; Parsons & Vézina, 2018). This links terms of trade to shifts in migrants' skill levels.

Remittances also play a crucial role. If all migrants send a fixed amount home, changes in migrant skill composition do not affect total remittances. However, if remittances vary with income, shifts toward higher-skilled migration could influence financial flows to origin countries.

The findings suggest that increased high-skilled migration benefits destination countries while having mixed effects on origin countries. Overall, global wealth rises by 0.6 %, supporting the hypothesis that skilled workers migrate to higher-productivity locations.

Aubry et al. (2016) employ a similar model but focus on the fiscal effects of migration, specifically its impact on state budgets and social benefits. To capture these effects, the authors modify the fiscal block of the model, incorporating two tax rates: consumption and labour income. While residents and immigrants face a uniform tax rate, government spending on children's education and transfers varies by migrants' origin.

Aubry et al. (2016) analyse two scenarios. In the first, public goods expand proportionally with population growth. In the second, government spending remains fixed. The findings suggest that immigration can have a positive fiscal effect by broadening the tax base and lowering the per capita cost of public goods. The results align with Biavaschi et al. (2020): destination countries benefit most, while origin countries bear the greatest losses. On average, the fiscal effect raises welfare by 0.4 %, though this is smaller than the market size effect, which increases wealth by 1 %. Alternative scenarios yield similar conclusions.

Overall, the studies indicate that migration can affect both origin and destination countries. The impact on residents' well-being can be either positive or negative, depending on the characteristics of the origin country, though migration generally poses a risk to well-being in most origin countries. For destination countries, migration typically has a positive impact, regardless of the migrants' skill levels. Migration is more beneficial for countries that are closer, as measured by trade levels or the

presence of diasporas. Despite these variations, general equilibrium models remain a valuable tool for migration analysis.

Conclusion

The literature review on migration revealed that general equilibrium models are becoming an increasingly prominent tool for analysing labour flows. Both the number of studies and citations in this area have been growing significantly each year.

These models incorporate various assumptions about firm and individual heterogeneity, preferences, and the nature of competition, whether perfect or monopolistic. Some models include geographical factors to analyse the impact of migration on citizens' well-being, while others emphasize the importance of distinguishing between low-skilled and high-skilled labour forces.

The various channels through which migration affects the economies of both origin and destination countries were emphasized. The effects on residents' well-being can be positive or negative, depending on the characteristics of the country of origin. However, migration generally has a positive impact on destination countries. Additionally, internal migration tends to increase overall productivity. The main shortcomings and limitations of the observed models were also discussed.

Modern migration models are based on models of trade between regions. They often consider the skills of migrants to precisely determine the impact of tightening or liberalizing migration rules. Migration is important for all regions of the world including Russia. According to research findings, Russia may experience a brain drain while simultaneously benefiting from an influx of low-skilled labour. However, it is essential to consider the social tensions associated with this phenomenon, which have received limited attention in the literature. A promising research direction is the development of an international migration model with heterogeneous firms and perfect competition. The division of the labour force into highly skilled and low-skilled workers presents a promising approach, as it considers the various channels through which migration impacts the economy.

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