Rekindling New Economic Geography in Times of COVID-19: Labor Mobility Responses to Health Shocks in Central and North America

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Abstract
This paper evaluates the potential responses of international labor mobility to the recent COVID-19 health shocks, using a New Economic Geography model inspired by recent events in Central and North America. The model suggests that the restraining impact of COVID-19 on migratory flows may retain potential emigrants in Mexico and Central America, enlarge the home market in the region, attract foreign and local businesses, and increase real wages. Moreover, this prediction unveils opportunities for the future from the opening of new, regular migratory pathways between Central America and Mexico. These would concentrate population and industry in Mexico, raise the market potential in the area and boost real wages in Mexico – and possibly in Central America as well – despite the partial deindustrialization of the Central American hinterland.

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Introduction

The spread of COVID-19 has reshaped economic and social structures, resulting in increasing levels of personal inequality in terms of economic opportunity. The spatial dimension of inequality has also been affected, as many academic scholars have recently confirmed the existence of an uneven geography of COVID-19, for a wide variety of territories (Ascani et al. 2021; Ascani, Faggian, and Montressor, 2021; Florida and Mellander 2022; Holmager et al. 2021; McCann, Ortega-Argilés, and Yuan. 2021; Rodríguez-Pose and Burlina 2021). Here we will focus on the capacity to turn labor mobility into a suitable instrument to deal with health shocks, using a framework based on New Economic Geography.

In general, New Economic Geography (henceforth NEG) methodologies have been left aside from the academic design of responses to the pandemic. However, solid theoretical and empirical work are both required to unravel the way in which countries and regions should fight COVID-19 shocks, and to draw pertinent policy recommendations. This is particularly relevant in the current context, where certain peripheral regions have been left behind and there are claims that it is important to explore new development policies (e.g. Eder 2019; MacKinnon et al. 2022; Rodríguez-Pose 2018).

Labor mobility is one of the most important ingredients of NEG, and it has become of greater interest during COVID-19, as travel restrictions and quarantines have increased governmental stringency (OECD 2020). Our analysis stems from the remarkable experience in the Central and North American subcontinent. This region is under tremendous strain because of increasing flows of refugees and migrants, who are fleeing the ravaging consequences of the pandemic, the subsequent economic recession, violence, and climate disasters.

“Mexico […] has gone from being predominantly a country of transit to a country of destination for thousands of asylum seekers, […] and now faces record numbers of new asylum claims this year, which may top 100,000” (UN Refugee Agency, UNHCR 2021). Therefore, this country seems to be becoming “a destination in its own right” (The Economist 2021): “[people] can spend years trying to get into the United States or spend those years building a life in Mexico”, where Central Americans “can do everything but vote”.

In the meantime, the COVID-19 crisis is continuing to interface with the hardship of frequent displacement toward the USA: migrants are especially vulnerable to criminal groups, the spread of the virus, and the strict US border policies that block asylum indefinitely (Assessment Capacities Project, ACAPS 2020; El Colegio de Mexico 2020). This pressing, contemporaneous reality is only one part of a tendency for global migration to shift “increasingly into the shadows” (Center for Strategic and International Studies, CSIS 2020) due to the impact of the pandemic on as many as 100 million
globally displaced people. These people are likely to find fewer regular migratory pathways in the years to come, which will perturb production chains and increase inequality worldwide. With this work we aim to suggest that, in the geographical environment under analysis, it is sensible to consider certain migratory alternatives, which may turn out to be mutually beneficial to both sending and recipient countries.

Our NEG model suggests that the migratory slowdown induced by COVID-19 could retain people in Central America and Mexico. Provided that at least certain conditions on increasing returns to scale, market clearing and trade costs are met, this will enlarge their local home markets, attract foreign investment, promote the emergence of local business, and increase real wages. Furthermore, if we accept that the sequel of COVID-19 will restrain international migration toward the USA, migration between the “Northern Triangle of Central America” (Honduras, Guatemala and El Salvador, henceforth the NTCA) and Mexico could provide welfare benefits to both these parties. The labor force could become less spread out in the area, the market potential of Mexico and the NTCA would consequently grow, and these countries’ relative income per capita would increase.

Although our analysis is depicted at country level, we have introduced the subnational dimension to achieve a framework empirically consistent with NEG. For this reason, as a first step we have estimated some of the model parameters using subnational data for US states. To the best of our knowledge, Puga’s (1999) model has not been applied to the data for this area of the world before. In fact, Hanson (2005b) parameterized, using data from US counties, the seminal article by Krugman (1991), which can be regarded as a particular case of Puga (1999). However, in Krugman (1991) some parameters, like the productivity of labor in the agricultural sector, take extreme values by assumption. Moreover, Hanson’s (2005b) structural estimation imposed identical real wages across the US states, which is not a prerequisite for our empirical strategy. Our parameterization follows the setting proposed by Bosker et al. (2010) and Bosker et al. (2012) for the European Union and China, respectively.

Migration between the NTCA and Mexico works here as a partial substitute for the sizeable net flows toward the USA in the past. In a sense, multiple analysts have often tried to prevent the Mexican migratory tide by industrializing the border (see e.g. the discussion by Rivera-Batiz (1986)). This paper shows that a regular pathway between the NTCA and Mexico could help to achieve that goal. However, Mexico simultaneously needs to handle pressing social and political problems to host these migrants. Our model may be far from capturing the whole complexity of this problem but displays new evidence that may be considered by policymakers.

The organization of the paper is as follows. Section 2 sketches a literature review and section 3 describes the current migratory reality in Central and North America. Section 4 elaborates on our NEG modelling framework. Finally, section 5 discusses the main conclusions and suggestions for further research.
Turning Labor Mobility into a Regional-Policy Instrument

After the world economy faced the last global recession, there was very little academic consensus on the general regional-policy solutions that would strengthen economic performance. Subsequently, the emergence of COVID-19 gave rise to a new shock that is still in progress, with multifaceted effects on economic growth (Capello and Caragliu 2021), trade flows (Baldwin and Tomiura 2020; Cardozo-Silva et al. 2021), factor mobility (Martin and Bergmann 2021; Goolsbee and Syverson 2021), tourism flows (e.g. Duro et al. 2021) and inequality (Ludovic et al. 2022). Our intention here is to combine several strands of the literature and set up an analytical model to explore alternative solutions to be considered for Central and North America.

When analyzing the geographical patterns of responses to unexpected shocks, most of the attention has been paid to Europe. However, the American continent is also an area with opportunities in the field, since its economic geography has experienced notable policy-induced transformations in previous decades. For instance, the signature of the former North American Free Trade Agreement (NAFTA) spurred a series of studies about the impact of lower trade barriers on welfare and the relocation of economic activity (e.g. Burfisher, Robinson, and Thierfelder 2001; Caliendo and Parro 2015; Levy and van Wijnbergen 1994; Treffer 2004). Moreover, Mexico’s reorientation of its wage gradients toward the United States was regarded as a paradigmatic effect of Washington consensus policies (Krugman 1996; Krugman and Livas-Elizondo 1996), or as a laboratory for testing the predictions of NEG models (Hanson 1996, 1997, 1998, 2003).

Gradually, the literature has also focused on the incidence of international migration between Mexico and the USA, which was often connected with specific labor markets and public finance (e.g. Hanson 2005a). Internal migration patterns within the United States (Crozet 2004; Fallah, Partridge, and Olfert 2011; Helliwell 1997; Kaplan and Schulhofer-Wohl 2017) and within Mexico (Arends-Kuenning, Baylis, and Garduño-Rivera 2019; Fernández-Huertas Moraga 2013; Patt et al. 2018) have been gaining attention as well. However, these studies do not consider the particular social and economic context derived from COVID-19.

To the best of our knowledge, only Shimizutani and Yamada (2021) have conducted an econometric analysis of the effects of the pandemic on migration and remittances, oriented to the resilience of one specific country: Tajikistan. They found that those households with remitting, international migrants could mitigate the adverse economic outcomes during the year 2020. However, space did not play a role in their analysis since they explored a country-wide panel micro-dataset without territorial disaggregation.

Numerous policy-oriented NEG papers have already developed more-than-two-location models of economic geography (e.g. Barbero, Behrens, and Zoﬁo 2018; Behrens et al. 2007; Crozet and Koenig-Soubeiran 2004; Krugman and Livas-Elizondo 1996; Monfort and Nicolini 2000). Nevertheless, this part of the literature has descended less often to the estimation and simulation of models analyzing
migratory reform. Important exceptions are, among others, the papers by Whalley and Zhang (2004) and Bosker et al. (2012), who explored a relaxation of the *Hukou* labor mobility restrictions in China. Moreover, Desmet, Nagy, and Rossi-Hansberg (2018) introduced different global migration scenarios in a dynamic model with innovation.

To the best of our knowledge, there exists burgeoning evidence of COVID-19 impacts on migration flows. However, these studies do not base their findings on numerical simulation with a theoretical NEG model (e.g. Ascani et al., 2021; Bloise and Tancioni 2021; Gong et al. 2020; Haddad et al. 2022; Maza and Hierro 2021). In addition, they focus on specific areas of China or Europe, making it difficult to extrapolate their results to other territories. Given the global nature of COVID-19, whose impact has been prominent worldwide, a deeper multiregional analysis aiming to shed light on its effect on international and internal migration may be desirable.

**Economic Geography and Migration Flows in Mexico, Central America and the USA**

Despite the great expectations to which they gave rise in Latin America, the NAFTA and CAFTA\(^1\) free trade agreements have apparently failed to keep pace with the demand for jobs and higher wages in the region (Audley et al. 2003). Although export manufacturing and labor productivity have grown considerably in Mexico, the losers from trade liberalization lie among the middle classes and small agricultural owners, who had to adjust, by themselves, to shocks related to import competition and the falling prices of raw materials. Rather than focusing on trade as an end in itself, topics of general interest like labor and environmental protection required a deeper international cooperation. In this sense, these agreements were for a long time unable to restrain migration from Mexico and Central America to the USA.

The exodus of Mexican migrants to the USA has been for decades the largest bilateral migration flow worldwide (Chort and de la Rupelle 2016). It was spurred by massive opportunity differentials, migration push-and-pull factors and the facilitation provided by social networks of friends and family who were already in the United States (Rosenblum and Brick 2011). Today, about 12 million immigrants from Mexico (and roughly 2 million from the NTCA) live in the United States, up from fewer than 1 million in the 1970s, and these countries account for 36% of all US immigrants. Therefore, the size, determinants and workings of this migratory tide have been far from homogeneous over time, and several historical stages can be differentiated.

First, there was a policy of laissez faire, prior to the Great Depression (1930s) when economic hardship created an anti-immigrant sentiment that limited these flows until WWII; secondly, a large-scale guest-worker system (the Bracero Program) was inaugurated during WWII until the mid-1960s; and finally, a mostly illegal system emerged following the passage of major immigration legislation in 1965, which gave rise to millions of migrants from new communities of origin settling in newer regional destinations, with a broader occupational profile. However, despite all the subsequent transformations, “immigrants from Mexico and the Northern Triangle of Central
America continue to have less education and lower incomes than natives and other immigrants, and with few legal visas available, most immigrants from the region are unauthorized" (Rosenblum and Brick 2011, 1).

More recently, starting in the mid-2000s, net immigration flows between Mexico and the United States have come to a standstill, and the links between this and the Great Recession have been carefully analyzed in the literature (Hanson et al. 2017; Passel, Gonzalez-Barrera, and D’Vera 2012; Villarreal 2014). Arguably, a reduction in the demand for low-skilled labor in sectors like construction, durables manufacturing and agriculture, accompanied by a Mexican demographic transition, the tightening of US immigration policies, and a relative macroeconomic stability in Mexico, accounts for this phenomenon. However, the high rates of emigration from the countries of Central America are still rising, often driven by climatic factors (e.g. drought, hurricanes, and earthquakes), family reunification in the USA, and the impact of violence and insecurity (Bárcena et al. 2018).

Nevertheless, automation and import competition from low-wage countries have generally deterred the low-skilled labor force from emigration. And “these changes have combined to create a period of low wage growth […] for all but the highest-earning US workers”. Therefore, “future immigration rates of young, low-skilled workers appear unlikely to rebound” in aggregate terms (Hanson et al. 2017, 2). This prospect should urge researchers to find new migratory pathways, which in the future could channel the population of this region affected by push factors. More importantly, the Northern and Central American subcontinent deserves further attention when analyzing migration patterns, because of the large and heterogeneous volumes of agents involved in the process.

The Model

The subsequent analysis will try to uncover some predictions associated with labor mobility reform in a comprehensive NEG model. The geographical mobility of labor always involves pecuniary externalities, which will affect both the area of net emigration and that of net immigration, giving rise to welfare alterations for those individuals who move and also for those who remain in their homeland. More specifically, despite the downward pressure on wages exerted by any recent immigration flow, in the presence of trade costs these new migrants will enlarge (reduce) the market size of their destination (source) country.

This will induce some firms to take advantage of that large local market potential by relocating toward the destination areas, or by directly starting anew there. Moreover, these new firms will engage in vertical (input–output) linkages with one another, which could reinforce the existing centripetal forces, although the latter will be (partially or completely) offset by product and labor market competition. In other words, any variation in the propensity of labor to migrate sets in motion a chain of causal events that will be explored here for the case of Central and North America.
Overview

Our model is an application of Bosker et al.’s (2012) NEG setting, adapted to the reality of the Northern American subcontinent. It considers a theoretical framework with three geographical blocks: the USA (1), Mexico (2) and the NTCA (3), three sectors: agriculture, industry, and a non-tradeable housing sector; and two factors of production: homogeneous labor and land. The industrial technology of the three blocks can show potentially different marginal costs.

Bosker et al.’s (2012) framework showed three basic differences with respect to Puga’s (1999) well-known theoretical contribution: (i) the setup was no longer equidistant between the locations in the model; (ii) migration costs (a minimum real wage differential threshold) were introduced, which prevented a full convergence in real wages; and (iii) a housing sector was included, which incorporated additional centrifugal forces to avoid extreme agglomeration.

In our model we add heterogeneous migration disutility (or a “home-biased preference”) among workers, so that even if it were completely costless for them to travel, some of them would always stay in their homeland. It is possible to observe from Figure 1 that, in order to get to the NTCA, US industrial exports must first go through Mexico, and vice versa. Therefore, the three blocks are located along a straight “line”, and Mexico is the central place or “hub”. Trade in industrial goods is then subject to iceberg transport costs, such that $\tau_{1,3} = \tau_{1,2} \times \tau_{2,3}$ (see Figure 1).

The local stocks of arable land, housing and labor in each geographical block $i$ are denoted by $K_i, H_i$ and $L_i$, respectively. The labor shares of the three blocks are endogenous in the model and are adjusted by the evolution of migration. Moreover, the local endowments of arable land and housing are constant and normalized as shares of the aggregate stocks in this area of the world.

Demand. As anticipated above, there are three economic sectors in each of the three locations: the agricultural and food sector ($F$), which serves as the numeraire and is traded costlessly across these blocks; an industrial sector ($M$); and a real estate sector ($H$). Consumers exhibit Cobb–Douglas preferences over the agricultural good, housing and a Constant Elasticity of Substitution (CES) composite of manufacturing.
varieties (or varieties for short), with industrial (housing) expenditure share $\gamma_m (\gamma_h)$, between zero and one. Trade in manufacturing varieties is subject to different transport costs for each block pairwise.

Maximizing the CES sub-utility function subject to the consumer’s budget constraint yields the individual demand for each variety $h$ ($d(h)$ in (1)), where $Y$ stands for the consumer income, $q$ is the manufacturing price index, and $\sigma$ and $p(h)$ are the elasticity of substitution and the c.i.f. price, respectively, of the varieties

$$d(h) = p(h)^{-\sigma} q^{\sigma-1} \gamma_m Y; q = \left( \int_0^n p(z)^{1-\sigma} dz \right)^{\frac{1}{1-\sigma}}$$  (1)

Firms also use varieties of intermediates as inputs, for which they too have an elasticity of substitution of $\sigma$. Therefore, the local demand for each variety depends on the spending by consumers and local firms. Therefore, the aggregate spending from location $i$ on all manufacturing varieties is

$$e_i = \gamma_m Y_i + \mu n_i p_i x_i$$  (2)

where $n_i(x_i)$ is the mass of produced varieties (the equilibrium output of any variety) in region $i$. The first term on the right-hand side is the local consumers’ income spent on manufactures, and the second is the expenditure on intermediates by local firms. The parameter $\mu$ measures the share of every firm’s total cost devoted to the purchase of intermediates and is an indicator of the strength of the vertical linkages between upstream and downstream firms.

Manufacturing supply. The manufacturing (or industrial) sector is monopolistically competitive. The production input in manufacturing is a Cobb–Douglas composite of labor, which receives a wage rate $w_i$, and intermediates. The total cost in region $i$ can thus be specified as follows

$$C(x_i) = q_i^\mu w_i^{1-\mu} c_i(\alpha + \beta x_i)$$  (3)

where $\alpha$ and $\beta$ are the fixed-cost and the marginal-input requirements for every variety. Following Bosker et al. (2012), the three regional blocks are allowed to differ exogenously in their productive efficiency, in a way that is inversely related to the value of $c_i$. Different levels of productive efficiency may reflect the heterogeneity in workers’ human capital between regional blocks.

As a result, the following profit function will be maximized (with respect to prices) by the local producers in region $i$

$$\pi_i = \sum_j \frac{p_j x_{ij}}{\tau_{ij}} - q_i^\mu w_i^{1-\mu} c_i(\alpha + \beta x_i)$$  (4)
where $\pi_i$ stands for the firm’s profits, $p_{ij}$ is the c.i.f. price applied to the market $j$ by a firm in region $i$, and by $x_{ij}$ ($\tau_{ij}$) we denote the units of good shipped to $j$ by any firm in location $i$ (the iceberg trade cost from region $i$ to $j$). Moreover, from (1) and (2)

$$x_{ij} = \tau_{ij}^{1-\sigma} p_{ij}^{\sigma} q_j^{\sigma-1} e_j$$

(5)

Profit maximization results in a f.o.b. price that shows a constant mark-up over marginal costs$^3$

$$p_i = \frac{\sigma \beta c_i}{\sigma - 1} d_i^{\mu} w_i^{1-\mu}$$

(6)

Finally, using the mark-up pricing rule in (6) and imposing the zero-profit (free-entry) condition on (4), it is possible to conclude that the break-even supply of any variety is constant in equilibrium. In particular, applying the normalizations $\alpha = \frac{1}{\sigma}$ and $\beta = \frac{\sigma - 1}{\sigma}$, the individual supply $x_i = 1$.

**Supply of food.** In this model, consumers’ income comes from three sources: local workers’ wages, agricultural rents, and the sale of a fixed local stock of housing ($H_i$). Agriculture produces a homogeneous good (our numeraire) under constant returns to scale and perfect competition. Its production in region $i$ depends on the available stock of land ($K_i$), such that

$$F_i = F(L_i^F) = L_i^{F\theta} K_i^{1-\theta}$$

(7)

By applying rent maximization, the aggregate agricultural rents in location $i$ are $R_i = (1 - \theta)K_i(\theta/w_i)^{\theta/(1-\theta)}$. Since a share $\gamma_h$ of the aggregate consumers’ income is devoted to housing, then

$$Y_i = w_i L_i + R_i$$

(8)

**Housing.** Every regional block (the United States, Mexico and Central America) has a fixed housing stock ($H_i$), which is non-tradeable internationally. The equilibrium condition in the competitive housing market simply states that house prices ($p_{H,i}$) are higher the smaller the available stock is, and the greater the amount of local income spent on housing. That is

$$p_{H,i} = \frac{\gamma_h Y_i}{H_i}$$

(9)

**Short-run equilibrium with trade costs.** The short-run equilibrium in this economy is characterized by product and factor market clearing, while the labor force is not yet allowed to relocate internationally. It is possible to describe this short-run
equilibrium by the interplay of four endogenous variables in each location: the share of local labor employed in the industrial sector \( \varepsilon_i \), the wage rate \( w_i \), the local level of expenditure in manufactures \( e_i \), and the manufacturing price index \( q_i \). More specifically, from agricultural rent maximization it is straightforward to derive the following

\[
e_i = 1 - \frac{L_i^F}{L_i} = 1 - \frac{K_i}{L_i} \left( \frac{\theta}{w_i} \right)^{1/\theta} \quad (10)
\]

Moreover, since a share \( (1 - \mu) \) of the manufacturing cost is spent on wages

\[
w_i \varepsilon_i L_i = (1 - \mu) n_i q_i^{\mu} w_i^{1-\mu} c_i \quad (11)
\]

From (11) it is then possible to solve, for the local mass of varieties that break even, in terms of the endogenous variables mentioned above

\[
n_i = \frac{\varepsilon_i L_i}{(1 - \mu) c_i \left( q_i \right)^{\mu}} \quad (12)
\]

Now by combining (2), (8) and (12)

\[
e_i = \gamma_m Y_i + \mu n_i p_i = \gamma_m \left( w_i L_i + (1 - \theta) K_i \left( \frac{\theta}{w_i} \right)^{\theta/1-\theta} \right) + \frac{\mu}{1 - \mu} \varepsilon_i L_i w_i \quad (13)
\]

Now we can obtain a closed-form expression for the wage rate by using (1) and the zero-profit condition for each individual firm

\[
x_i = 1 = \sum_{j=1}^{3} e_j p_j^{-\sigma} q_j^{\sigma - 1} t_{ij}^{1-\sigma} \quad (14)
\]

If we now plug (6) into (14) and solve for the wage rate

\[
w_i = c_i q_i^{-\mu/1-\mu} \left[ \sum_{j=1}^{3} e_j q_j^{\sigma - 1} t_{ij} \right]^{1/\sigma (1-\mu)} \quad (15)
\]

This last equation will be very useful when we later parameterize the model with US data. Finally, by plugging (12) into the expression for the local price index in (1), we get

\[
q_i^{1-\sigma} = \sum_{j=1}^{3} n_j p_j^{1-\sigma} t_{ij}^{1-\sigma} = \frac{1}{1 - \mu} \sum_{j=1}^{3} e_j L_j c_j^{-\sigma} q_j^{-\mu\sigma} w_i^{1-\sigma (1-\mu)} t_{ij}^{1-\sigma} \quad (16)
\]
As a result, the short-run equilibrium is specified in each location by equations (10), (13), (15) and (16).

**Long-run equilibrium and labor mobility.** The migration of labor takes place in the long-run equilibrium, in response to real-wage differentials between the geographical blocks. Given the consumer preferences, the real wage ($V_i$) – understood here as the indirect utility of workers – can be expressed as follows

$$V_i = \frac{w_i}{q_i q_{h,i}^{\gamma}}$$  (17)

Workers will flow toward the locations with the highest real wages, although the existence of idiosyncratic home-biased preferences prevents their complete equalization. This feature of the model acknowledges the presence of disutility from migration, and workers will not migrate unless this disutility is offset by real-wage differentials.

In our setting we follow Faini (1996) to assume that every worker’s home bias is summarized by the realization of a random variable $\theta$, which is distributed across the population according to a Pareto density function: $f(\theta) = \frac{\varepsilon}{\theta^{\varepsilon+1}}$, with $\theta > 1$, $\varepsilon > 0$. The higher $\theta$ is, the stronger will be the home-biased preference of the worker. For instance, a Mexican would migrate to the USA only if $V_{USA}/V_{MEX} > \theta$. Therefore, the share of the original population from Mexico that remains in the country is

$$\phi_{MEX} = \int_{V_{USA}/V_{MEX}}^{\infty} f(\theta) d\theta = \min\left\{\left(\frac{V_{MEX}}{V_{USA}}\right)^{\varepsilon}, 1\right\}$$  (18)

As a result, the share of the Mexican population that migrates, $1 - \phi_{MEX}$, increases with the real-wage differential, and $\varepsilon$ becomes an indicator of the willingness to migrate. If $\varepsilon$ takes a very high positive value, the immobile share of the original Mexican population will be very low, since $(V_{MEX}/V_{USA}) < 1$ (see (18)).

If we denote by $L_i$ the share of the labor force originally coming from region $i$, and by $L_i$ the actual share that lives and works there, the equations describing labor mobility in the first scenario of our simulations can be specified as follows

$$L_{MEX} = \overline{L}_{MEX}\phi_{MEX}$$
$$L_{NTCA} = \overline{L}_{NTCA}\phi_{NTCA}$$
$$L_{USA} = L_{USA} + \overline{L}_{MEX}(1 - \phi_{MEX}) + \overline{L}_{NTCA}(1 - \phi_{NTCA})$$  (19)

We will explore the long-run equilibrium allocation of population and industrial firms across the three regional blocks, once the equations (17)–(19) are incorporated into the system defined by (10), (13), (15) and (16). We will then undertake a comparative-static exercise by (gradually) modifying the parameter $\varepsilon$, which captures the responsiveness of migration to welfare differences across space.
Parametrization

Derivation of the wage equation. An appropriate parametrization of the model is key to the accuracy of the results, and must be adapted to the reality of the regions. To that purpose, we collect information on wages, employment, GDP, distances, ruggedness of terrain and climatic variables for 49 continental US states, spanning from 2017 to 2021, to construct a dyadic database. The final goal is to obtain an estimate of the elasticity of substitution (\(\sigma\)) and the trade cost function (\(\tau_{ij}\), expressed in terms of the distance between \(i\) and \(j\)). These data allow for an estimation of the wage equation (15), along the lines followed by Bosker et al. (2012), which results in the following log-linearized, alternative econometric specifications

\[
\ln(w_{it}) = \alpha + \frac{1}{\sigma} \ln \left( \sum_{j=1}^{49} e_j q_j^{\sigma-1} \tau_{ij}^{1-\sigma} \right) + \beta_i + \beta_t + \varepsilon_{it} \tag{20}
\]

\[
\ln(w_{it}) = \alpha + \frac{1}{\sigma} \ln \left( \sum_{j=1}^{49} e_j q_j^{\sigma-1} \tau_{ij}^{1-\sigma} \right) + \gamma \ln X_{it} + \beta_i + \varepsilon_{it} \tag{21}
\]

\[
q_j = \left\{ \lambda_j w_j^{1-\sigma} + \left( 1 - \lambda_j \right) \bar{w}^{1-\sigma} (TD_{j,center})^{\delta(1-\sigma)} \right\}^{1/(1-\sigma)} \tag{22}
\]

The first specification (in (20)) incorporates the market-access term in brackets, together with state and time fixed effects, whereas in (21) we replace the individual fixed effects by regional control variables (\(X_{it}\)). The variable \(e_j\) is approximated with state \(j\)’s GDP in each time period.

The empirical strategy to recover the local price indices is based on the introduction of equation (22). This equation includes, within the Dixit–Stiglitz structure, the local wage (\(w_j\)), the local share of US aggregate employment (\(\lambda_j\)), the average wage of other states (\(\bar{w}\)), and the trade cost function (\((TD_{j,center})^{\delta}\)). \(D_{j,center}\) stands for the minimum distance between state \(j\) and the three main US regional markets (i.e. New York, California and Illinois).

Our explicit trade cost function in equations (20) and (21) can be specified as follows

\[
\tau_{ij} = (TD_{ij})^\delta \tag{23}
\]

Accordingly, the parameter \(\delta\) measures the elasticity of trade costs with respect to geographical distance, and \(T\) is an additional, positive scale parameter. The bilateral distance between USA and Mexico (Mexico and El Salvador) was established between the country capitals, and equals 2335.8 (1680.9) miles.

The wage equations (20) and (21) are estimated by non-linear least squares (NLS), and the following two estimates are recovered for the parameters \(\sigma\) and \(\delta\).
\[ \sigma = 9.63; \quad \delta = 0.04 \]  

(24)

Notice that the specifications in (20) and (21) will only be a reasonable approximation to (15) provided that the relevance of the input–output linkages – measured by the parameter \( \mu \) – is not very high. Furthermore, our choice of the other parameter values (\( \mu, \theta, \gamma_m \) and \( \gamma_h \)) is based on input–output tables for the US economy and US 2021 data on real personal consumption expenditure by major type of product.

**Variables and data sources.** Our database comprises 49 states in the United States (excluding Hawaii). We gather our variables from different statistical sources. Wages and employment data come from the US Bureau of Labor Statistics. For the Terrain Ruggedness Index (TRI), we follow the prior estimation by Shaver, Carter and Shawa (2019). For the climate variables, we rely on the US National Oceanic and Atmospheric Administration (NOAA). Finally, data on regional population are collected from the Organization for Economic Cooperation and Development (OECD, Regional Statistics), while data on educational attainment by state come from the St Louis Fed. Regarding distances between counties, we have harmonized data from different sources: county distances are mainly collected using the National Bureau of Economic Research (NBER) County Distance Database, while internal distances within counties are computed using the method suggested by Head and Mayer (2000).

The list of variables is presented as follows (subscripts \( I \) and \( t \) refer to state and year, respectively, while \( \ln \) is the natural logarithm): \( SEAI \) is a control variable that takes the value 1 if the state can be accessed by sea and 0 otherwise. \( TEMP_{it} \) is the average yearly temperature of the state, while \( PRECIP_{it} \) stands for the average yearly precipitation in the state. \( TRI_i \) is the Terrain Ruggedness Index and, finally, \( BPOP_i \) is the percentage of the population with a bachelor’s degree. We have incorporated three additional variables in this list: \( PDENSITY_{it} \) is the regional population density in year \( t \), while \( EMP_{it} \) and \( WAGE_{it} \) are the regional employment and wages, respectively. Table A2 in the Appendix contains the basic descriptive statistics for these variables.

**Results of the parametrization.** Our modelling approach is based on that of Bosker et al. (2010) and (2012), which led us to include economic and geographical variables. In particular, we acknowledge the impact on economic performance of terrain ruggedness (Nunn and Puga 2012) and geography (Albalate et al. 2022) at the subnational level. However, certain time-invariant geographical determinants may be perfectly collinear with regional fixed effects. For this reason, we consider three specifications in Table A1 in the Appendix. These specifications are described in the following paragraphs.

While column (1) shows the regional determinants that are time-invariant at the subnational level, such as the Terrain Ruggedness Index, columns (2) and (3) drop such determinants by including regional fixed effects. The difference between columns (2) and (3) stems from the inclusion of additional explanatory variables, such as the percentage of the population with a bachelor’s degree. The inclusion of fixed effects can contribute to the alleviation of omitted variable bias. In addition to that, we control for
potential problems of endogeneity by introducing a two-step procedure: first, we instrument regional income with an initial regression that relates income to its own lagged values, a time trend and a sea dummy, and then we estimate (20) and (21) using the fitted values obtained in the first stage.

The results presented in Table A1 show that the values of the parameters of interest do not change substantially in the different specifications. Concerning the explanatory variables, their coefficients are positive and significant, with the exception of the coefficient for terrain ruggedness, which is positive but non-significant. The values from the specification in column (3) such as $\sigma = 9.63$ and $\delta = 0.04$, are chosen as the baseline parametrization. The resulting values obtained for the main parameters are summarized in Table 1.

Concerning the endowments of labor, arable land and housing, we select the actual stock shares as a fraction lying between zero and one. Housing stocks are allocated following the same pattern as the population, as was done by Bosker et al. (2012). The results are shown in Table 2.

Finally, the values of the country-specific (marginal) cost indicators ($c_i$) are chosen to generate realistic welfare differences in PPP* terms. In particular, we select $c_{USA} = 1, c_{MEX} = c_{NTCA} = 1.4$. That is, marginal costs in the industrial sector tend to be higher in Mexico and the NTCA relative to the USA.

### Numerical Simulations and Results

It is well known that COVID-19 generated a strong rise in the costs of migration, to the extent that migration was drastically restrained through the impact of travel restrictions.

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**Table 1.** Parameterization of Relevant NEG Models.

| Parameter | Meaning | Our choice of values – US states | Bosker et al. (2010) – Europe | Bosker et al. (2012) – China |
|-----------|---------|----------------------------------|---------------------------|---------------------------|
| $\sigma$  | Elasticity of substitution between manufacturing varieties | 9.63 | 7.122 | 5.886 |
| $\gamma_m$ | Share of consumers’ income spent on manufactures | 0.6 | 0.7 | 0.343 |
| $\gamma_h$ | Share of consumers’ income spent on housing | 0.16 | 0 | 0.118 |
| $\mu$ | Share of firms’ revenue spent on intermediates | 0.58 | 0.284 | 0.511 |
| $\theta$ | Labor elasticity in the agricultural production function | 0.11 | 0.234 | 0.879 |

Source: Authors’ own work.
and quarantines. However, the home-bias preference of the population did not necessarily rise, and it may have decreased as a result of natural disasters, violence, and vulnerability. As discussed above, multiple forms of vulnerability are being suffered by numerous groups in the Mexican and Central American blocks.

Therefore, we will characterize the first scenario in the simulations as a general, symmetric rise in the migration propensity \((2)\), countered by forceful constraints on migration, which actually prevented the flow from taking place at all. As a result, we will observe how the three regional blocks would have been affected by migration in the absence of the COVID-19 restrictions. Therefore, we will assess the outcome of the restrictions in terms of local population shares, welfare, industrial output and the local share of the labor force employed in manufactures.

First, given the existing differences in economic opportunity, the Mexican and Central American populations will directly choose the USA as a migration destination. Consequently, our scenario 1 combines equations (10) and (13)–(19) above, to derive the evolution of the main endogenous variables in the model. Later, scenario 2 characterizes the outcome when the migration flows are confined to the NTCA–Mexico pathways, and the size of the USA population remains unaltered.

**Scenario 1: Variations in migration propensity toward USA.** As we can observe in the first row of Figure 2, labor mobility restrictions caused a general increase in real wages (the welfare measure for local workers) in the USA, Mexico and the NTCA. In the case of the USA, the arrival of new migrants would have had a depressing effect on local wages and a soaring impact on the price of housing. These conventional, neoclassical forces would have overturned the agglomeration economies derived from the local expansion in variety (i.e. the mass of local firms) and the subsequent vertical linkages. In particular, the third row of Figure 2 captures the levels of industrial output, which in the model are identical to the local masses of variety \((n_i)\), since \(x_i = 1\).

Although migration would have increased industrial variety in the USA, the overall impact on native workers’ welfare would have been negative, because of the prevalent downward (upward) pressure on nominal wages and housing prices.

In the case of Mexico and the NTCA, the restrictions constrained the potential migrants in their home countries, which preserved the original size of their markets and avoided the closure of many local businesses. Unlike the US evolutions, in these
countries the agglomeration economies proved to be more important than the (neo-classical) effects of a larger labor supply or higher real estate prices.

**Scenario 2: Variations in migration propensity between the NTCA and Mexico.** The likely effects of the previous shock, in scenario 1, could also open up some future opportunities, at least for Mexico. If the reluctance to host new migrants due to COVID-19 decayed over time, then reinstating – or even widening – the NTCA–Mexico migratory pathways may be in the interests of the latter country.

This implication could be suggested by slightly modifying the model and replacing the previous equation (19) by the following ones in (25)

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**Figure 2.** Simulation analysis for the variation in migration propensity toward the USA. Source: Authors’ own work.
The reason is that, if the US immigration policy remained strict, this sort of “internal migration” between the two southern communities could provide a window of opportunity for Mexico, by concentrating the labor force, the aggregate purchasing power, and the industrialization there. We develop these findings in Figure 3 by simulating the variation in migration propensity between the NTCA and Mexico.

Welfare for the remaining population in the NTCA could fall. However, this last result is not fully robust since, with much lower trade costs, the size of the home market would be less important for businesses, labor costs would become crucial, and many

\[
\begin{align*}
L_{MEX} &= L_{MEX} + L_{NTCA}(1 - \varphi_{NTCA}) \\
L_{NTCA} &= L_{NTCA}\varphi_{NTCA} \\
L_{USA} &= L_{USA}
\end{align*}
\]

Figure 3. Simulation analysis for the variation in migration propensity between the NTCA and Mexico. Source: Authors’ own work.

\[L_{MEX} = L_{MEX} + L_{NTCA}(1 - \varphi_{NTCA}) \]
\[L_{NTCA} = L_{NTCA}\varphi_{NTCA} \]
\[L_{USA} = L_{USA} \]
firms would stay in Central America despite the shrinking labor supply. These circumstances will be explored in the robustness checks conducted in the following section.

Robustness checks. It is possible to question the geometric distribution of the locations displayed in Figure 1. Perhaps it would be more realistic if trade exchanges between the USA and the NTCA bypassed Mexico by means of air travel or maritime connections. Therefore, in the following analysis Mexico will not play the role of a hub: the three regional blocks will be located on the vertices of an equilateral triangle. The distance between them will be, for instance, equal to that existing between Mexico and El Salvador (1680.9 miles), although we also analyzed the result with the USA–Mexico distance mentioned above, with similar results.

Scenario 1 with symmetric trade costs: Migration toward the USA. In this first scenario of the robustness section, we assume the existence of symmetric trade costs. These findings can be found in Figure 4 below.

In this case (see Figure 4 above) the previous results are preserved qualitatively for a wide range of values of the migration propensity ($\pi$). In comparison with Figure 2, we can observe that deindustrialization in the NTCA will be a much milder phenomenon because of the symmetry and lower magnitude of the trade costs (see the third and fourth rows of Figure 4), which reduces the relevance of market size in firms’ location decisions (see e.g. Puga (1999)).

Scenario 2 with symmetric trade costs: Migration between the NTCA and Mexico. Finally, in Figure 5 we replicate the same scenario as in Figure 4 but for migration propensity between the NTCA and Mexico.

In comparison with the previous section 4.3.2, it is possible to observe that the situation improves considerably for the NTCA workers who remain in their home country, since, once trade costs are lower in the symmetrical setup, the weaker home market is no longer a crucial consideration for firms. Therefore, the abandonment by these firms of the NTCA will not be as important as before, the local demand for labor will stay high, and real wages will even increase there as the result of neoclassical forces.

In general, to the extent that migrants follow market potentials, they will relocate toward regions with better access to markets, which will attract imports from foreign countries for the benefit of the local population. In this sense, this form of “internal migration” may work as a partial substitute for the past, sizeable flows to the USA in terms of the welfare of the southern communities. This is a sufficiently general principle that could be extrapolated to the analysis of different countries.

As an additional robustness check, we have carried out a similar simulation exercise, but assuming that the productivity differentials in manufacturing are much higher than in the previous cases ($c_{USA} = 1$, $c_{MEX} = c_{NTCA} = 3$). Figures A1 and A2 in the Appendix show that now the USA-Mexico disparity in terms of real wages is much stronger and variations in the migration propensities have only slight welfare effects.
Nevertheless, the qualitative patterns in terms of welfare gains and losses are maintained. This can be observed by comparing the Figures 4 and 5 with the Figures A1 and A2 in the Appendix.

**Conclusions and discussion**

In this paper, we have explored some of the implications that can be presumed to follow from the COVID-19 migratory shock in Central and North America, in terms of the distribution of population, industrialization and welfare. It is suggested that the current economic downturn in the subcontinent might be alleviated by new migratory pathways between the NTCA and Mexico, which would be mutually beneficial as long as international trade costs were sufficiently low. These results have been achieved using a
comprehensive NEG setting, based on the work of Bosker et al. (2012) and adapted to this geographical environment.

Although our simulation analysis is developed at the country level, the parameterization considers the geography of US states, making such results highly consistent with findings derived from place-based policies. In particular, our results pose important policy implications, which become of further interest for policymakers especially in the COVID-19 aftermath. We have found several efforts in the academic literature to promote place-based policies (Duranton and Venables 2018; Kline and Moretti 2013; Neumark and Simpson 2015), but always before COVID-19. However, after the arrival of COVID-19 it is fundamental to redesign effective place-based development policies, and an NEG theoretical setting can be useful in achieving this goal by identifying specific needs.

In addition, it is necessary not only to shed light on the economic relations generated after COVID-19 in Central and North America, but also to do so in the context of a new

Figure 5. Simulation analysis of the variation in migration propensity between the NTCA and Mexico, assuming symmetric trade costs. Source: Authors’ own work.
political environment. This can be observed in changes in the economic relationships between Mexico and the United States, which now seem to be progressively reconciled. We find that it is particularly relevant that appropriate migration policies in Northern and Central America are reinforced, since they have been gaining importance after COVID-19 and some problems derived from them are persisting.

Addressing migration flows should not, however, be restricted exclusively to Northern and Central America. In fact, our findings could be extrapolated to other shocks and territories. For instance, the economic shock derived from the current armed conflict between Russia and Ukraine has given rise to large volumes of migrants to other countries, demanding effective migration policies worldwide.

While we have fulfilled our research objectives, we acknowledge the existence of limitations that may be addressed by future work. First, introducing an NEG model with numerous locations, closer to the actual distribution of cities and regions in the area, may be desirable to complement the results in line with recent findings (e.g. Barbero, Behrens, and Zofío 2018). Furthermore, the estimation of the wage equation could be further refined by allowing for the impact of vertical linkages on regional price indices, which could provide more accuracy in the parametrization. Finally, this analysis could be extended by operationalizing the concept of regional resilience, which has been useful in explaining previous economic shocks (Christopherson, Michie, and Tyler 2010; Faggian et al. 2018). However, it is fundamental to pay attention to the distinction between evolutionary (Boschma 2015) and engineering resilience (Di Pietro, Lecca, and Salotti 2021; Martin and Sunley 2015; Pudelko, Hundt, and Holtermann 2018).

Appendix

Table A1. Results of NEG estimation for US states, 2017-2021.

|          | (1)          | (2)          | (3)          |
|----------|--------------|--------------|--------------|
| \( \sigma \) | 6.562*** (0.134) | 10.32*** (0.0502) | 9.636*** (0.0775) |
| \( \delta \) | 0.0504*** (0.0245) | 0.0404*** (0.00337) | 0.0430*** (0.00601) |
| \( SE_{Ai} \) | 0.0251*** (0.00319) | 0.560*** (0.00419) |
| \( \ln TEMP_{it} \) | 0.164*** (0.00984) |
| \( \ln PRECIP_{it} \) | 0.0126*** (0.00170) |
| \( \ln TRI_{i} \) | 0.00209 (0.00150) |
| \( \ln BPOP_{it} \) | 0.771*** (0.00834) |
| Constant | -3.244*** (0.0655) | -1.802*** (0.0145) | 0.0935*** (0.00569) |
| State FE | X | X |
| Year FE | X | X |
| Observations | 8648 | 8648 | 8648 |

Note: Standard errors in parentheses, such as ***\( p < 0.01 \), **\( p < 0.05 \), *\( p < 0.1 \).
Table A2. Main descriptive statistics.

| Variable | Observations | Mean   | Std Dev | Min   | Max   |
|----------|--------------|--------|---------|-------|-------|
| PRECIP<sub>t</sub> | 8648 | 39.60  | 16.33   | 5.19  | 85.6  |
| TEMP<sub>t</sub>    | 8648 | 54.67  | 8.45    | 30.5  | 73    |
| BPOP<sub>t</sub>    | 8648 | 27.18  | 4.85    | 17.3  | 38.2  |
| SEA<sub>t</sub>     | 8648 | 0.47   | 0.50    | 0.5   | 462.85|
| TRI<sub>t</sub>     | 8648 | 92.47  | 76.41   | 8     | 293   |
| PDENSITY<sub>t</sub> | 8468 | 78.37  | 104.70  | 0.5   | 462.85|
| EMP<sub>t</sub>     | 8648 | 2,853,282 | 3,189,246 | 253,905 | 1.76 × 10<sup>7</sup> |
| WAGE<sub>t</sub>    | 8648 | 56,659.24  | 10,794.31 | 39,832 | 101,920 |

Figure A1. Simulation analysis of the variation in migration propensity toward the USA, assuming symmetric trade costs and higher productivity differentials ($c_{USA} = 1, c_{MEX} = c_{NTCA} = 3$). Source: Authors’ own work.
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Notes

1. Central American Free Trade Agreement.
2. C.i.f. refers to Cost, Insurance and Freight.
3. F.o.b refers to Free on Board.
4. Purchasing Power of Parity.

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