Internal Migration and Recovery from Large Crises*

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December, 2025

Abstract

This paper studies internal migration adjustments during the South Korean crisis of 1997-1998, and their impacts on ensuing recovery and macroeconomic resilience. I empirically find that there were increases in migration inflows to regions specializing in sectors that expanded significantly during the post-crisis recovery, resulting in increased employment in these regions. I develop a dynamic spatial general equilibrium model to quantify the contributions of migration adjustments on the post-crisis recovery. Due to sudden shocks induced by the crisis, reallocating labor across regions through migration can increase output and foster recovery. During the recovery, higher mobility raises sectoral labor reallocation and aggregate real GDP growth, while making production more spatially concentrated. The GDP gains from higher mobility are larger in post-crisis turbulent times than normal times without crises.

Keywords: large crises, migration, labor reallocation, resilience
JEL Codes: F16, F31, R23

*I thank discussants Fernando Leibovici and Runjuan Liu for insightful comments and suggestions, as well as Costas Arkolakis, Dominick Bartelme, Andres Blanco, Barthélémy Bonadio, Agostina Brinatti, Jaesung Choi, Kerem Cosar, Javier Cravino, Andres Drenik, Kyle Handley, Ryan Kim, Andrei A. Levchenko, John McLaren, Myunggyu Shim, Jagadeesh Sivadasan, Sebastian Sotelo, Linda Tesar, Jing Zhang, and seminar participants at EIIT, KIEP, University of Michigan, SCIEA, University of Virginia, and Yonsei for helpful comments. E-mail: jaedo.choi@utexas.edu.

1. Introduction

In the aftermath of large crises, economies experience sharp contractions in economic activity and abrupt trade adjustments, with disproportionate effects across sectors due to differences in tradability and across regions due to variation in industrial composition. Internal migration can serve as an important adjustment margin, facilitating faster recovery and enhancing an economy's resilience to adverse macroeconomic shocks, as pioneered by Blanchard and Katz (1992). However, in emerging market economies, where large crises tend to occur more frequently, this migration channel is often muted by substantial migration frictions.[1] This raises an important policy-relevant question: how do migration frictions affect post-crisis recovery and macroeconomic resilience in emerging market economies?

This paper studies internal migration adjustment after the South Korean crisis of 1997-1998. The main contributions of this study are twofold. First, it provides novel empirical evidence on migration adjustments post-crisis. It shows that people migrated more frequently to regions specializing in sectors that experienced significant expansions during the recovery, resulting in higher employment growth in these regions. Second, it develops a model to quantify this migration adjustment on subsequent recovery and macroeconomic resilience.

Exploiting cross-sectional variation in industrial composition, I empirically document how migration and employment responded to local labor market shocks induced by the crisis. Using long-difference specifications, I regress changes in migration inflows (outflows) on the "Bartik" local labor market shocks of destination (origin). The Bartik shock is constructed by interacting initial industry employment shares and national-level growth in gross output by industry. I find that migration inflows (outflows) of a region increased by 10% (decreased by 5%) three years after the crisis, compared to another region with one standard deviation lower Bartik shock. Regions that received more migration inflows experienced larger employment increases by 3%. Event-study specifications show that these results from the long-difference specifications were not driven by pretrends. The findings remain robust with additional controls, such as regional exposure to balance sheet effects and changes in unemployment rates, housing prices, and amenities.

Motivated by these findings, I build a dynamic spatial general equilibrium model with forward-looking migration and trade. South Korea is modeled as a small open economy. The crisis is formulated in a reduced-form fashion as five exogenous time-varying shocks to productivity, labor supply, foreign demand, import price, and trade deficits. These shocks capture prevalent features of emerging market economies after large crises, such as substantial drops in TFP and output, reductions in labor supply, export expansions, collapses in imports, and rapid declines in trade deficits.

Households make labor supply decisions on which sectors to work in, how many hours to work,

[1] Selod and Shilpi (2021) document that low income countries tend to face higher migration frictions. Bryan and Morten (2019) document higher internal migration frictions in Indonesia than in the US. Tombe and Zhu (2019) study higher migration frictions in China due to the Hukou system in China.

and where to live. Migration decisions are modeled as dynamic discrete choices. They choose locations based on real income, option values of being in one region, and non-monetary migration frictions measured in terms of utility. In response to the crisis, their optimal migration decisions shape the labor reallocation process across regions, with higher migration frictions impeding this process.

The model is calibrated to data at the region-sector level. I derive a regression model from the theoretical model and estimate the migration elasticity using an IV strategy. The IV exploits cross-sectional variation in industrial composition, similar to those used for the empirical analysis. The exogenous shocks are extracted by exactly fitting the model to the data. Region-sector gross output, sectoral producer price indices (PPIs), and aggregate real GDP growth pin down productivity shocks. Region-sector employment shares pin down labor supply shocks, while export and import shares pin down foreign demand and import price shocks, respectively. Trade deficits are directly taken from the data. The dynamic equilibrium path of the model reproduces the annual data on these variables.

The calibrated model successfully replicates the two empirical findings when applying the same specifications used in the empirical analyses to the model-generated data. Labor supply shocks, which can be microfounded based on labor market frictions, are the most critical factor in replicating these findings. When labor supply shocks are turned off, the model fails to replicate the findings, suggesting that labor supply side is important in understanding post-crisis dynamics of employment and migration.

Using the calibrated model, I assess how the economy would have adjusted differently in response to the crisis depending on migration mobility. I compare the transition paths of the baseline economy, where migration mobility aligns with levels observed in the data, to those of counterfactual economies with different levels of migration mobility. These counterfactual economies are constructed by feeding in migration friction shocks. I consider hypothetical scenarios with temporary changes in mobility levels, including full-mobility, no-mobility, and empirically plausible reductions in migration frictions inferred from observed migration flows. These plausible reductions may reflect potential outcomes of migration policies during the recovery, such as temporarily subsidizing rural workers to move to urban regions.

Higher mobility resulted in greater sectoral labor reallocation and higher aggregate real GDP growth, thereby fostering recovery. After the crisis, completely removing migration frictions would have resulted in GDP growth between 1999-2001 being 4.4 percentage points higher compared to the baseline mobility level. Because the crisis had uneven impacts across region-sectors, higher mobility brought larger gains in GDP during post-crisis turbulent times than normal times without crises, simulated by turning off the crisis-related shocks. The increase in GDP growth rates from completely removing migration frictions was 200% larger during post-crisis turbulent times. Moreover, higher mobility led to a greater geographical concentration of production in regions specializing in sectors that expanded more during the recovery, making regional adjustments more responsive. While the framework does not explicitly incorporate monetary costs of increasing mobility, the calculated GDP effects provide useful bounds for policymakers to assess whether policies aimed at improving mobility are worth pursuing during post-crisis recoveries.

This paper contributes to the literature on the consequences of large crises (e.g., Burstein et al., 2005; Pratap and Urrutia, 2012; Gopinath and Neiman, 2014; Kim et al., 2015; Cravino and Levchenko, 2017; Blaum, 2024; Drenik et al., 2018; Ates and Saffie, 2021). Kohn et al. (2020) and Queralto (2020) document sluggish recoveries after crises due to financial frictions and declines in innovation efforts, respectively. This paper studies how internal migration mobility can foster post-crisis recoveries. Following Eaton et al. (2016), I invert the dynamic model to match the data moments and structurally recover the underlying shocks. I find that labor supply shocks are the dominant force driving post-crisis migration flows observed in the data, suggesting that labor supply factors play a key role in post-crisis recovery. This finding is consistent with Drenik (2016), Blanco et al. (2022), and Blanco et al. (2025) who document that labor market frictions, nominal wage rigidity and unions, play an important role in explaining post-crisis employment dynamics.

This paper is also related to the recent quantitative spatial and trade literature on internal migration (e.g., Dix-Carneiro, 2014; Giannone et al., 2023; Artuc et al., 2025). Bryan and Morten (2019) and Tombe and Zhu (2019) study spatial misallocation and long-run TFP losses due to internal migration frictions in a static setting. This paper explores how migration frictions affect macroeconomic resilience after the crisis in a dynamic setting building on dynamic spatial models with discrete choices developed by Artuc et al. (2010) and Caliendo et al. (2019).

The structure of this paper is as follows. Section 2 describes the data and the background of the crisis. Section 3 presents the empirical evidence. Section 4 describes the quantitative model and its calibration procedure. Section 5 presents the quantitative results. Section 6 concludes.

2. Data and Stylized Facts

2.1 Data

The final dataset combines information on region-sector employment shares, region-sector gross output, region-to-region migration flows, regional population, sectoral trade, and other sectoral variables. The sample period spans from 1995 to 2002. I aggregate data to 54 regions based on their electoral districts and 15 sectors, ensuring that each region has positive employment for all 15 sectors. Appendix A provides more details.

I construct region-sector employment shares from the Census on Establishment. This dataset covers the universe of formal establishments with one or more employees at finely disaggregated geographic levels for all sectors. On average, approximately 2.9 million establishments are covered by this dataset across the sample period. This dataset is representative of the national economy. On average, sum of regional employment in a sector accounts for 78% of total sectoral employment as

Table 1: Descriptive Statistics

Variable	Mean	SD	Median
Overall mfg. employment share	0.28	0.13	0.24
Top 5 export-intensive mfg. employment share	0.19	0.12	0.17
Outflow migration rate	0.11	0.03	0.10

Notes. This table reports the descriptive statistics of the dataset. $N = 432$. There are 15 sectors and 54 regions. The sample period is between 1995-2002.

reported in the KLEMS database. Employment shares are computed by summing up employment across establishments within region-sectors and dividing by total regional employment. Appendix Figure A8 reports coverage by sector. I construct region-sector gross output by combining the Census of Establishment, state-sector level gross output, and IO tables from the WIOD 2013 release (Timmer et al., 2015). National-level gross output by industry is allocated to 16 states using state-sector gross output data. Within each state-sector, region-sector gross output is allocated using region-sector employment from the Census of Establishment.

Region-to-region migration flows are calculated as total number of migrants between origins and destinations divided by lagged population of origins. The sample is restricted to individuals aged 20 to 55, focusing on working-age population. I obtain sectoral imports, exports, and IO tables from the WIOD and the Bank of Korea. I aggregate countries except for South Korea as the rest of the world. Sectoral PPIs are obtained from the OECD STAN Database, and region-level residential housing price and consumer price index (CPI) data from the Statistics Korea.

Table 1 presents the descriptive statistics. The average employment shares in the overall and top 5 most export-intensive manufacturing sectors were 19% and 28%, respectively. On average, 11% of people moved to different regions annually. When aggregating 54 regions up to 16 states, comparable with the average land size of US counties, the average outflow rate is 7.2%.[2] This rate is approximately 1 percentage point higher than the annual inter-county migration rates reported in Molloy et al. (2011).

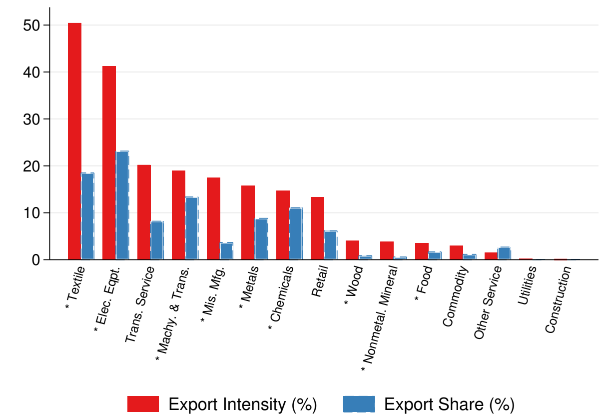
2.2 Stylized Facts

In late 1997, South Korea was hit by the crisis and the government requested for a bailout package from the IMF. In 1998, the country experienced sharp contractions of economic activities, with GDP growth declining by 11 percentage points from 5.2% to −5.8%, and the real exchange rate depreciating by 26%. Between 1998-2001, the economy recovered with real GDP growth rebounding to pre-crisis levels. In 2001, the government eventually repaid the bailout loan to the IMF. I outline three stylized facts during this period, summarized in Figure 1.

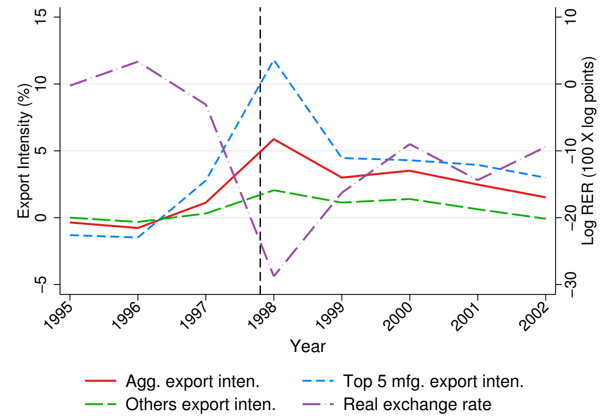
Fact 1. Large increases in exports with sectoral heterogeneity. Panel A shows substantial variation in sectoral export intensities defined as shares of exports to gross output. Manufacturing sectors

[2] South Korea is similar in size to Indiana in the US, and regions in my analysis are, on average, 66% the size of US counties, smaller than the average US commuting zone.

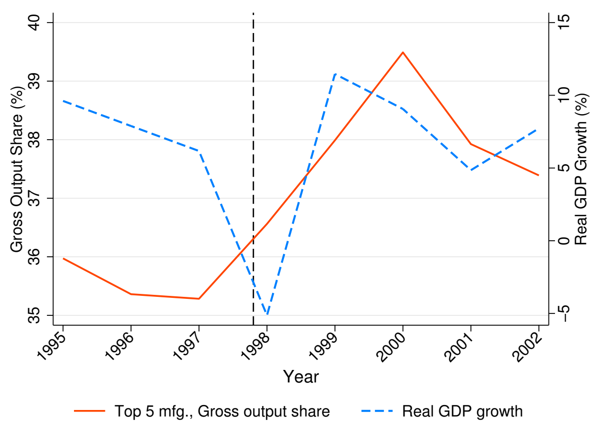
Figure 1: Stylized Facts after the South Korean Crisis



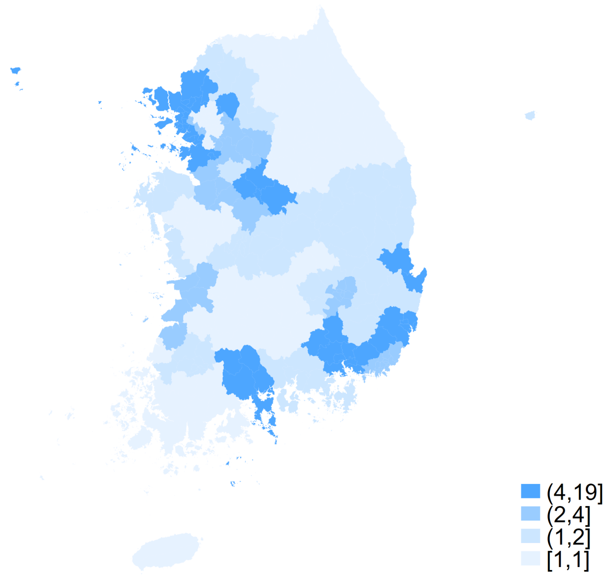
A.Sectoral heterogeneity in export intensity



B. Export intensity & log RER



C. Gross output share & Real GDP growth



D. Top 5 mfg. emp share

Note. Panel A shows the sectoral export intensities and export shares in 1994. An asterisk * denotes manufacturing sectors. In Panel B, the export intensities and log real exchange rate around the crisis are plotted, distinguishing the overall sectors (red solid line), top 5 most export-intensive manufacturing sectors (blue dashed line), and remaining sectors (green long-dashed line). The purple long-dashed line represents log real exchange rate multiplied by 100. Each export intensity is normalized by the median between 1995-1997. Panel C displays shares of gross output from the top 5 sectors to total gross output (red solid line) and real GDP growth (blue dashed line). Panel D plots employment shares of the top 5 sectors in 1994. Regions are colored based on quartiles, with darker shades indicating higher values.

tended to have higher export intensities and export shares. Based on these intensities, I define the top 5 most export-intensive manufacturing sectors.[3]

With the 26% depreciation in the real exchange rate, the aggregate export intensity soared from 15% in 1997 to 19% in 1998, remaining approximately 2 percentage points higher in subsequent

[3]The top 5 sectors include textiles, electrical equipment, machinery and transportation equipment, metals, and chemicals. The miscellaneous manufacturing sector, despite having higher export intensity than some included sectors, was not classified among the top 5 due to its low export shares and ambiguous classification.

years (Panel B). This aggregate increase is primarily attributed to heightened export intensities of the top 5 sectors. Normalizing the export intensities by their medians between 1995-1997 for ease of comparison, the intensity of the top 5 sectors increased by 4.9 (2.2) percentage points in 1998 (2000) relative to 1997, surpassing the other sectors.

Fact 2. Large drop in real GDP and expansion of export-intensive sectors during the recovery. During the recovery periods between 1999-2001, gross output shares of the top 5 sectors gradually increased, peaking in 2000, accompanied with their export expansions (Panel C). This fact suggests that contributions to the post-crisis recovery varied across sectors, with the top 5 sectors playing a particularly important role.

Fact 3. Regional heterogeneity in industrial composition. Panel D illustrates regional variation in employment shares of the top 5 sectors. The shares were geographically concentrated in the northwestern and southeastern regions. The regional variation suggests that the post-crisis recovery could have been driven asymmetrically across regions depending on their industrial composition.

Discussion. After the sharp contraction of real GDP, the recovery period saw notable contributions from more export-intensive sectors. This was partly due to their export expansions, which may signify underlying factors such as faster productivity growth or increased foreign demand due to the depreciation. Given the asymmetric impacts of the crisis across region-sectors, workers may have migrated to regions specializing in sectors that experienced larger expansions during the recovery. In the next section, I leverage cross-sectional variation in industrial composition to provide empirical evidence supporting this hypothesis.

3. Empirical Evidence

3.1 Migration Flow

I begin by examining how migration inflows and outflows responded to local labor market shocks of destinations and origins between 1997-2000, respectively, using long-difference specifications:

$$\Delta \ln \mu_{nm} = \beta \text{Bartik}_m + \mathbf{X}_m' \gamma + \delta_n + \varepsilon_{nm}, \quad \Delta \ln \mu_{nm} = \beta \text{Bartik}_n + \mathbf{X}_n' \gamma + \delta_m + \varepsilon_{nm}. \tag{3.1}$$

Dependent variables are changes in log migration flows from region n to m, defined as shares of total migrants from n to m to lagged population in n. Bartik_m is a standardized Bartik local labor market shock, which will be discussed below. $\mathbf{X}_n$ is region n's observables. δ_n are regional fixed effects. ε_{nm} are the error terms. Any time-invariant pair characteristics, such as distance, are differenced out. Standard errors are clustered at the origin and destination levels in the two specifications, respectively. Both specifications are weighted by origins' initial population in 1994.

The specifications are at the region-to-region pair level, incorporating the bilateral nature of location choices.[4] Zero observations are not an issue because only 2 out of 2,916 observations are dropped due to zero values.

The Bartik shock is computed as the employment-weighted sectoral growth of gross output, excluding own region, between 1997-2000:

$$\text{Bartik}_n = \sum_{j=1}^{J} \frac{\text{Emp}_{nj,94}}{\sum_{j'=1}^{J} \text{Emp}_{nj',94}} \times \Delta \ln \text{Gross Output}_{(-n)j,00}. \tag{3.2}$$

ΔGross Output$_{(-n)j,00}$ captures national-level changes in sector j common components, unrelated to region n's characteristics, during the recovery, such as sector-common productivity shocks or export expansions. Higher values of the Bartik shock imply that regions initially had higher employment shares in sectors that expanded larger during the recovery, and therefore, experienced relatively better labor market conditions.

Panels A and B of Table 2 report the results on migration inflows and outflows, respectively. Column 1 presents the estimated coefficients without any additional controls. The coefficients are statistically significant at the 1%. Regions with one standard deviation higher Bartik shock experienced 11% higher inflows and 3% fewer outflows.

Additional controls. In columns 2-9, I include additional controls. Appendix B.1 describes the construction of these variables in detail. Column 2 accounts for heterogeneous trends by including the initial log employment in 1994. Column 3 includes pre-crisis changes in migration flows between 1995-1996 to address potential confounding preexisting trends. The results remain stable.

Kim et al. (2015) examined negative balance sheet effects on South Korean firms after the crisis due to currency depreciations and foreign debt compositions. To capture regional exposure to these effects, I construct a variable following Kim et al. (2015) and include this variable in column 4. The result remain robust, suggesting that lower growth in gross output in the Bartik shock may already reflect these negative balance sheet effects.

During the crisis, the aggregate unemployment rate rose from 2.6% to 7.0% between 1997-1998, which could have influenced migration flows. Column 5 controls for changes in log regional unemployment rates between 1995-2000, obtained from Population Census.[5]

To allow for potential heterogeneous trends depending on migration frictions, I include three proxies for migration frictions in column 6. First, I construct a variable that measures differences in industrial composition between two regions using the Mahalanobis distance of the initial employment shares between them. Second, I construct an index of regional conflicts based on the Mahalanobis

[4] Borusyak et al. (2022) demonstrate that conventional migration regression at the region level, which ignores the bilateral nature of location choices, may lead to a violation of the SUTVA condition.

[5] Because regional unemployment rates in 1997 are unavailable, I use the 1995 level as a proxy for the 1997 level, assuming stability between 1995-1997. This aligns with stable aggregate unemployment rates around 2.2% between 1994-1996.

Table 2: OLS Long-Difference. Migration Responses to the Crisis

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Panel A. Migration inflow								
Bartik_m	0.11***	0.11***	0.11***	0.12***	0.10***	0.10***	0.11***	0.10***	0.09**
	(0.04)	(0.04)	(0.04)	(0.04)	(0.03)	(0.03)	(0.03)	(0.04)	(0.03)
Adj. R^2	0.22	0.22	0.22	0.22	0.25	0.24	0.25	0.24	0.28
	Panel B. Migration outflow								
Bartik_n	−0.03*	−0.05***	−0.03*	−0.04**	−0.03**	−0.03*	−0.04***	−0.03*	−0.04***
	(0.02)	(0.01)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)
Adj. R^2	0.53	0.55	0.53	0.53	0.53	0.54	0.56	0.53	0.56
Initial emp		✓							✓
Pretrend			✓						✓
Balance sheet				✓					✓
Unemployment					✓				✓
Migration frictions						✓			✓
Housing price							✓		✓
Amenity								✓	✓
Origin (Dest.) FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
# Cluster	54	54	54	54	54	54	54	54	54
N	2,914	2,914	2,914	2,914	2,914	2,914	2,914	2,914	2,914

Note. Standard errors are in parenthesis. *: $p < 0.1$; **: $p < 0.05$; ***: $p < 0.01$. Standard errors are clustered at the destination and origin levels in Panels A and B, respectively. The table reports the OLS estimates of equation (3.1). In Panels A and B, the regression specifications are $\Delta \ln \mu_{nm} = \beta \text{Bartik}_m + \mathbf{X}_m' \gamma + \delta_n + \varepsilon_{nm}$ and $\Delta \ln \mu_{nm} = \beta \text{Bartik}_n + \mathbf{X}_n' \gamma + \delta_m + \Delta\varepsilon_{nm}$, respectively, weighted by the initial population of origins in 1994. The dependent variables are changes in log migration flows between 1997-2000. Bartik_n is the standardized Bartik shock (equation (3.2)). Controls included are: log initial employment (column 2), pretrends in migration flows (1995-1996) (column 3), regional exposure to balance sheet effects (column 4), changes in log unemployment rates (1995-2000) (column 5), differences in industrial composition, regional conflict index, and log distance (column 6), changes in residential housing prices (1997-2000) (column 7), changes in the amenity index (1995-2000) (column 8), and all controls jointly (column 9). See Appendix B.1 for more details on the additional controls. All specifications of Panels A and B include origin and destination fixed effects, respectively.

distance in candidates' vote shares in the 1992 presidential election, which serves as a proxy for cultural, economic, and political conflicts between regions.[6] Lastly, I include log bilateral distance.

Concerns about omitted variable bias can arise if housing prices or amenities responded to the Bartik shocks. Despite the short-run time horizon mitigating this concern, I provide formal evidence that this is not the case. Column 7 includes changes in log residential housing prices between 1997-2000. In column 8, following Diamond (2016), I construct an amenity index as the first principal component of bundles of observable amenities between 1995-2000, and include its changes as a control.[7]

[6] See Appendix B.1 for more details on institutional setting behind the index of regional conflicts.

[7] This includes the number of retail establishments per capita, number of education service establishments per capita,

In column 9, I control for all additional variables jointly. The estimates with these additional controls remain within one standard deviation from those without any controls.

Commuting. Another concern is that the migration results may be contaminated by changes in commuting patterns after the crisis due to the granularity of spatial units. To address this concern, I conduct two exercises, reported in Appendix Table B3. First, I regress changes in bilateral commuting flows between 1995-2000, obtained from the population census, on the Bartik shock.[8] The results show no significant effects, suggesting that migration estimates are unlikely to be affected by commuting patterns at the current level of aggregation. Second, I rerun the specifications after dropping pairs with distances smaller than 200km (120 miles). This subsample, unlikely to be influenced by commuting, yields coefficients close to the baseline estimates.

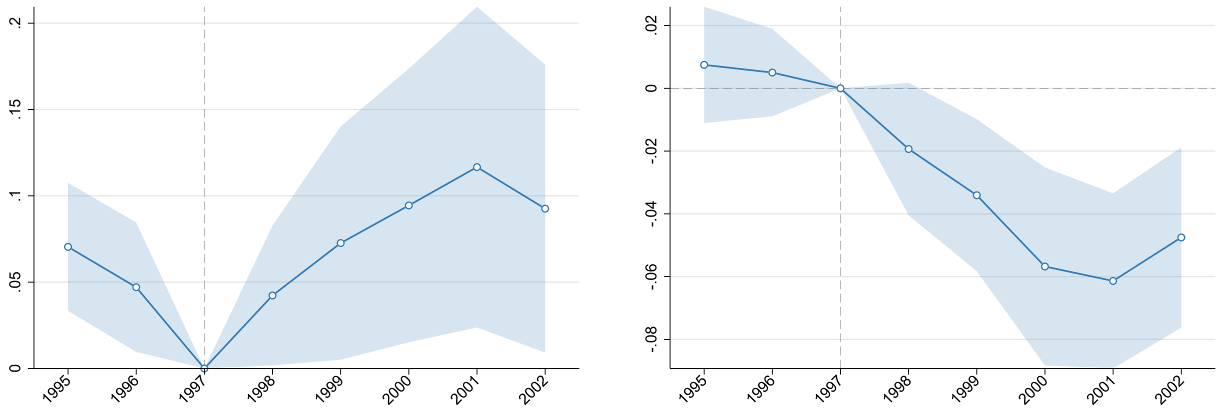
Shift-share diagnostics. The aforementioned specifications are based on shift-share research design. If the exogeneity of the initial shares holds conditional on the controls and fixed effects, the estimates can be causally interpreted (Goldsmith-Pinkham et al., 2020). The Rotermberg weights are highly skewed, with the top 5 sectors explaining about 75% of the positive weights (Appendix Tables B5 and B6). Following the diagnostic proposed by Goldsmith-Pinkham et al. (2020), I regress top 5 employment shares on other observables that might be related to potential confounding factors (Appendix Table B7). Correlations with employment shares in the top 5 sectors that were most exposed to balance sheet effects, unemployment rates, housing prices, and amenity in the initial year are statistically insignificant with low R-squared values. This implies that the findings are unlikely driven by confounding factors related to these observables.

Additional robustness checks. Appendix Table B4 presents robustness checks for alternative subsample and clustering, spatial correlations across nearby regions and regions with similar initial shares, and LASSO control selection. I run the analysis excluding regions with large industrial complexes and the capital, Seoul, where manufacturing sectors are concentrated (Choi and Levchenko, 2025) (column 1). Although this reduces variation in the data, the estimates remain stable. The results are also robust to two-way clustering at both origin and destination levels (column 2). To address potential spatial correlations, I use spatial HAC standard errors (Conley, 1999; Colella et al., 2021) with different bandwidths (columns 3-5), spatial correlation principal components (SCPC) (Müller and Watson, 2022) (columns 6-8), and standard errors adjusted for regions with similar initial employment shares (Adão et al., 2019) (column 9). Finally, using the LASSO method (Belloni et al., 2014), I flexibly select controls and their interaction terms up to the third order (column 10).

shares of workers using public transportation, number of factories per capita, and shares of white-collar occupation workers and business service establishments per capita. All variables had positive loadings except for the number of factories (Appendix Table B2).

[8] For most of the pairs, commuting flows are zero. Specifically, 2,450 out of 2,916 pairs of commuting flows are dropped due to zero values. The predominance of zero flows mitigates concerns related to commuting impacts.

Figure 2: Event Study. Migration Responses to the Crisis



A. Inflow B. Outflow

Note. Panels A and B illustrate the estimated β_τ in equation (3.3) for migration inflows and outflows, respectively. All specifications are weighted by the initial population of origins in 1994. The 95% confidence intervals are reported. Standard errors are clustered at the origin and destination levels in Panels A and B, respectively. The black dashed line indicates the year of the crisis. The dependent variables are log migration shares between origins and destinations. The coefficients in 1997 are normalized to zero. Panel A includes origin-year and pair fixed effects, while Panel B includes destination-year and pair fixed effects. All specifications include the initial log employment, log unemployment rates, regional balance sheet exposure, log housing prices, and the amenity index of destinations or origins, all of which are interacted with the event-time dummies. See Appendix B.1 for more details on the additional controls.

Event study. As shown in Panel B of Figure 1, the top 5 sectors experienced the largest gross output growth, explaining most of the variation in the long-difference specifications. If there were pretrends for regions with higher top 5 shares before the crisis, the estimates from the long-difference specifications could be contaminated by these pretrends. To investigate pretrends and dynamic effects, I employ the following event-study specifications:

$$\ln \mu_{nmt} = \sum_{\tau=-3}^{4} \beta_\tau (D_t^\tau \times \text{Empsh}_{m(n)t_0}^{\text{top5}}) + \sum_{\tau=-3}^{4} (D_t^\tau \times \mathbf{X}_{m(n)t_0})' \gamma_\tau + \delta_{nm} + \delta_{n(m)t} + \varepsilon_{nmt}. \tag{3.3}$$

$\text{Empsh}_{m(n)t_0}^{\text{top5}}$ is the initial top 5 employment shares in region m (or n), standardized. D_t^τ are the event-time dummies. δ_{nm} are time-invariant pair fixed effect. $\delta_{n(m)t}$ are origin-year (or destination-year) fixed effects. $\mathbf{X}_{m(n)t_0}$ includes initial values of the additional controls included in the long-difference specifications, all interacted with the event-time dummies. I normalize β_{-1} to zero. Standard errors are clustered at the origin and destination levels in the two specifications, respectively.

Figure 2 presents the estimates. The magnitudes of the estimated coefficients in 2000 align with those from the long-difference specifications. No pretrends are observed for migration outflows. However, for migration inflows, there are pretrends in the opposite direction to the estimates. Even if they persisted after the crisis, they would bias down the estimates and the estimates would be lower bounds for the true impacts. Nonetheless, due to these pretrends, I investigate sensitivity to potential violations of the parallel trend assumption, following Rambachan and Roth (2023), detailed in Appendix B.2.1. The estimates remain robust to this exercise (Appendix Figure B9).

3.2 Regional Employment

I next show that regions with larger migration inflows experienced greater employment expansions during the recovery. For 1997-2000, I run

$$\Delta y_n = \beta \text{Bartik}_n + \vartheta \widetilde{\text{Bartik}}_{-n} + \mathbf{X}_n' \gamma + \varepsilon_n. \tag{3.4}$$

Because this regression is at the regional level, nearby regions' labor market conditions may affect region n's outcomes through migration linkages, potentially violating the Stable Unit Treatment Values Assumption. For example, if region m experiences a larger Bartik shock than region n, migration flows from m to n decrease while flows from n to m increase, resulting in negative spillover effects on region n's employment.

To address this issue, I include $\widetilde{\text{Bartik}}_{-n}$ that captures the spatial spillover effects due to migration, as proposed by Borusyak et al. (2022):

$$\widetilde{\text{Bartik}}_{-n} = \sum_{m \neq n} \frac{0.5(\text{Migrants}_{nm,94} + \text{Migrants}_{mn,94})}{\text{Population}_{n,93}} \times \text{Bartik}_m. \tag{3.5}$$

$\widetilde{\text{Bartik}}_{-n}$ is the weighted average of other regions' Bartik shocks, excluding region n, with weights given by the average number of migrants between two regions relative to lagged population in the initial year. Higher weights are assigned to regions more connected through migration flows.

To examine pretrends and dynamic effects, I run the following event study specification:

$$y_{nt} = \sum_{\tau=-3}^{4} \beta_\tau (D_t^\tau \times \text{Empsh}_{nt_0}^{\text{top5}}) + \sum_{\tau=-3}^{4} (D_t^\tau \times \widetilde{\text{Empsh}}_{-n,t_0}^{\text{top5}})' \vartheta_\tau + \sum_{\tau=-3}^{4} (D_t^\tau \times \mathbf{X}_{nt_0})' \gamma_\tau + \delta_n + \delta_t + \varepsilon_{nt}, \tag{3.6}$$

where $\widetilde{\text{Empsh}}_{-n,t_0}^{\text{top5}}$ is the weighted average of other regions' top 5 employment shares, with the same weights in equation (3.5).

For both the long-difference and event-study specifications, I consider three dependent variables: log total employment, employment in the top 5 sectors, and employment in the remaining non-top 5 sectors. I include a similar set of observables used for the migration analysis. Bartik_n, $\text{Empsh}_{nt_0}^{\text{top5}}$, $\widetilde{\text{Bartik}}_{-n}$, and $\widetilde{\text{Empsh}}_{(-n)t_0}^{\text{top5}}$ are standardized. The models are weighted by the initial employment.

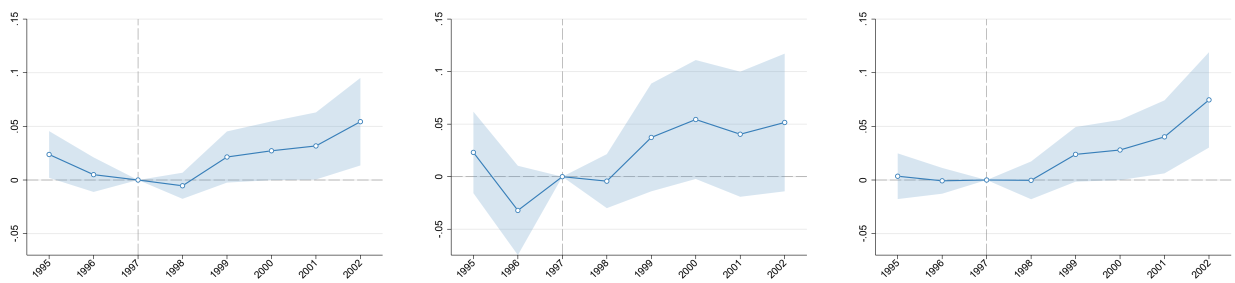
Table 3 reports the estimates from the long-difference specifications. On average, a region experienced 3%–5% increase in total employment growth compared to another region with one standard deviation lower Bartik shock. This region also experienced higher employment growth in not only the top 5 sectors, but also the remaining non-top 5 sectors. The estimates of $\widetilde{\text{Bartik}}_{-n}$ are negative, implying that favorable shocks in nearby regions reduced employment in region n. This aligns with the

Table 3: OLS Long-Difference. Employment Responses to the Crisis

Dep.	Δ log total emp			Δ log top 5 emp			Δ log non-top 5 emp		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Bartik_n	0.05***	0.04***	0.03**	0.07**	0.06**	0.06*	0.04***	0.04***	0.03**
	(0.01)	(0.01)	(0.01)	(0.03)	(0.03)	(0.03)	(0.01)	(0.01)	(0.01)
$\widetilde{\text{Bartik}}_{-n}$		−0.01*	−0.02***		−0.02**	−0.04***		−0.01	−0.01*
		(0.00)	(0.01)		(0.01)	(0.01)		(0.00)	(0.01)
Controls			✓			✓			✓
Adj. R^2	0.31	0.33	0.44	0.17	0.20	0.29	0.32	0.33	0.39
N	54	54	54	54	54	54	54	54	54

Note. Robust standard errors are in parenthesis. *: $p < 0.1$; **: $p < 0.05$; ***: $p < 0.01$. The table reports the estimates of equation (3.4), weighted by the initial employment in 1994. In columns 1-3, 4-6, and 7-9, the dependent variables are changes in log total employment, employment in the top 5 sectors, and employment in the non-top 5 sectors between 1997-2000, respectively. $\text{Bartik}_{n(m)t_0}$ and $\widetilde{\text{Bartik}}_{(-n)(m)t_0}$ are the Bartik shock (equation (3.2)) and the weighted average of the Bartik shock of nearby regions (equation (3.2)), respectively, both standardized. Columns 3, 6, and 9 include pretrends in the dependent variables (1995-1996), regional balance sheet exposure, changes in log unemployment rates (1995-2000), changes in log housing price (1997-2000), and changes in the amenity index (1995-2000). See Appendix B.1 for more details on the additional controls.

Figure 3: Event Study. Employment Responses to the Crisis



A. Log total emp B. Log top 5 emp C. Log non-top 5 emp

Note. The 95% confidence intervals, based on robust standard errors, are reported. This figure illustrates the estimated β_τ of $\text{Empsh}_{nt_0}^{\text{top5}}$ in equation (3.6), weighted by the initial employment in 1994, where $\text{Empsh}_{nt_0}^{\text{top5}}$ is the standardized top 5 employment shares in 1994. In Panels A, B, and C, the dependent variables are log total employment, employment in the top 5 sectors, and employment in the remaining sectors, respectively. The coefficients in 1997 are normalized to zero. All specifications include the initial regional balance sheet exposure, log unemployment rates, log housing prices, and amenity index, all of which are interacted with the event-time dummies. See Appendix B.1 for more details on the additional controls. All specifications include region and year fixed effects.

migration analysis, because favorable shocks in nearby regions would have induced more outflows from region n, reducing its employment. The increase in non-top 5 sectors' employment is consistent with local multiplier effects, where an influx of labor into the top 5 sectors boosts labor demand in remaining sectors.

The event study in Figure 3 results reconfirm these findings. Regions with higher initial top 5 shares, which experienced larger Bartik shocks, also saw higher employment growth in both the top 5 and remaining sectors. The increase in top 5 employment began only after the crisis, consistent with the surge in top 5 gross output shares in Panel C of Figure 1. The estimates of $\widetilde{\text{Empsh}}_{-n}^{\text{top5}}$ are imprecisely estimated.

I conduct the same robustness checks and shift-share diagnostics similar to those for the migration analysis and the results remain robust (Appendix Table B8 and Figure B10).

4. Quantitative Framework

Motivated by the empirical findings, I develop a quantitative model for counterfactual analysis.

4.1 Model

4.1.1 Environment

The world is divided into Home and Foreign, corresponding to South Korea and the rest of the world. Home is a small open economy that takes the world import prices as given but faces downward-sloping demand for its products in the international market. Home is composed of N regions, indexed by $n, m \in \mathcal{N} = \{1, \ldots, N\}$. There are J sectors, indexed by $j, k \in \mathcal{J} = \{1, \ldots, J\}$. Each region is spatially linked through costly trade and migration. Internal and international trade are subject to iceberg trade costs. For a unit of any sector j variety goods shipped from n to m for $n, m \in \mathcal{N} \cup \{F\}$ where F denotes Foreign, $d^j_{nm} \geq 1$ units have to be shipped. I normalize $d^j_{nn} = 1, \forall n \in \mathcal{N}$.

Each region is populated with representative households. They are forward-looking with perfect foresight and a discount factor $\beta \in (0, 1)$. They live hand-to-mouth, spending all of their income on consumption each period. They supply labor and migrate across Home regions subject to migration frictions. Home total population is normalized to one.

4.1.2 Production and Trade

Intermediate goods producer. Each region n produces a unique sector j intermediate good variety. A representative intermediate goods producer of each region-sector produces a variety using Cobb-Douglas technology with shares γ^H_j and γ^k_j:

$$q_{njt} = A_{njt} H_{njt}^{\gamma^H_j} \prod_{k=1}^{J} (M^k_{njt})^{\gamma^k_j}, \qquad \gamma^H_j + \sum_{k=1}^{J} \gamma^k_j = 1. \tag{4.1}$$

A_{njt} denotes productivity, H_{njt} labor input, and M^k_{njt} sector k material input used by sector j. Under cost minimization, unit cost of production is

$$c_{njt} = \frac{1}{A_{njt}} \left(\frac{W_{njt}}{\gamma^H_j} \right)^{\gamma^H_j} \prod_{k=1}^{J} \left(\frac{P_{nkt}}{\gamma^k_j} \right)^{\gamma^k_j}, \tag{4.2}$$

where W_{njt} is region-sector nj's wage and P_{njt} is price of sector j intermediate inputs in region n.

Final goods producer. Final goods are non-tradable. They can be used as material inputs or final consumption goods. They are the constant elasticity of substitution aggregate of sector j intermediate goods from Home regions q_{njt} and Foreign q_{Fjt}:

$$Q_{njt} = \left(\sum_{m=1}^{N} q_{mjt}^{\frac{\sigma-1}{\sigma}} + q_{Fjt}^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}. \tag{4.3}$$

σ is the elasticity of substitution. The final goods market is perfectly competitive and free entry ensures zero profits. The price index is

$$P_{njt}^{1-\sigma} = \sum_{m=1}^{N} (d_{mn}^{j} c_{mjt})^{1-\sigma} + (d_{Fn}^{j} P_{jt}^{F})^{1-\sigma}. \tag{4.4}$$

P_{jt}^{F} are sector j import prices exogenous to Home.

Trade. Region n's sector j expenditure shares on intermediate goods from region m and Foreign are

$$\pi_{mnt}^{j} = \frac{(d_{mnt}^{j} c_{mjt})^{1-\sigma}}{\sum_{m'=1}^{N} (d_{m'n}^{j} c_{m'jt})^{1-\sigma} + (d_{Fn}^{j} P_{jt}^{F})^{1-\sigma}} \quad \text{and} \quad \pi_{Fnt}^{j} = \frac{(d_{Fn}^{j} P_{jt}^{F})^{1-\sigma}}{\sum_{m=1}^{N} (d_{mn}^{j} c_{mjt})^{1-\sigma} + (d_{Fn}^{j} P_{jt}^{F})^{1-\sigma}}. \tag{4.5}$$

Region-sector nj's export values are

$$\text{EX}_{njt} = (d_{nF}^{j} c_{njt})^{1-\sigma} D_{jt}^{F}, \tag{4.6}$$

where D_{jt}^{F} is sector j Foreign demand exogenous to Home.

4.1.3 Household

Preference and labor supply. Region n households choose consumption C_{nt} and supply working hours h_{nt} to maximize

$$\ln U_{nt} = \ln \left(C_{nt} - \frac{1}{1+\frac{1}{\psi}} h_{nt}^{1+\frac{1}{\psi}} \right), \qquad C_{nt} = \prod_{j=1}^{J} (C_{njt})^{\alpha_j}, \qquad \sum_{j=1}^{J} \alpha_j = 1,$$

subject to budget constraints: $P_{nt} C_{nt} = (1 + \iota_t) W_{nt}$, where W_{nt} is their wage and ι_t is an exogenous tax that rationalizes trade imbalances as is standard in the trade literature. ι_t makes the ratio of per capita expenditure to per capita income vary exogenously over time: $\iota_t = \frac{\sum_n \sum_j (\text{IM}_{njt} - \text{EX}_{njt})}{\sum_n W_{nt} h_{nt} L_{nt}}$, where IM_{njt} is sector j import values of region n. Households have Cobb-Douglas preferences over consumption with expenditure shares α_j. The ideal price index is $P_{nt} = \prod_{j=1}^{J} (P_{njt}/\alpha_j)^{\alpha_j}$.

The utility-maximizing working hours only depend on within-period regional real wages:

$$h_{nt} = \left(\frac{(1 + \iota_t) W_{nt}}{P_{nt}} \right)^{\psi} \tag{4.7}$$

and the indirect utility function is

$$\ln U_{nt} = \ln \left(\frac{1}{1 + \psi} \left(\frac{(1 + \iota_t) W_{nt}}{P_{nt}} \right)^{1+\psi} \right).$$

Each household contains a continuum of workers with measure one indexed by $\omega \in [0, 1]$. Each worker is ex-ante identical but ex-post heterogeneous due to different ability draws across sectors, received anew each period after households make migration decisions. Each worker is characterized by an ability vector $\varepsilon_t^{\omega} = (\varepsilon_{n1t}^{\omega}, \ldots, \varepsilon_{nJt}^{\omega})$, where $\varepsilon_{njt}^{\omega}$ represents worker ω's efficiency units of labor that can be supplied to sector j. These draws are independently and identically distributed from a multivariate Fréchet distribution across regions and periods: $F_{nt}(\varepsilon_t) = \exp(-\sum_{j=1}^{J} E_{njt} \varepsilon_{njt}^{-\theta})$ with the shape parameter $\theta > 1$. The location parameters E_{njt} vary at the region-sector-period level, with higher values indicating higher probabilities of drawing larger labor efficient units.

Conditional on chosen working hours h_{nt} common across workers, sectoral labor supply is determined by households' optimal allocation of their workers across sectors to maximize total sum of wages earned by them. They allocate worker ω to sector j only if sector j offers the highest labor income over other sectors: $W_{njt} \varepsilon_{njt}^{\omega} \geq W_{nkt} \varepsilon_{nkt}^{\omega}, \forall k \in \mathcal{J}$. Shares of workers allocated to sector j are

$$\lambda_{njt} = \frac{E_{njt} W_{njt}^{\theta}}{\sum_{j'=1}^{J} E_{nj't} W_{nj't}^{\theta}}. \tag{4.8}$$

Up to normalization, region n's total labor supply in sector j, in units of effective labor, is

$$H_{njt} = E_{njt} \left(\frac{W_{njt}}{W_{nt}} \right)^{\theta-1} \left(\frac{W_{nt}}{P_{nt}} \right)^{\psi} L_{nt}, \tag{4.9}$$

where the regional wage index is

$$W_{nt} = \Big(\sum_{j=1}^{J} E_{njt} W_{njt}^{\theta} \Big)^{\frac{1}{\theta}}. \tag{4.10}$$

Labor supply shocks E_{njt} are exogenous shifters of region-sector labor supply curves.

The disutility of labor supply is an extension of Greenwood et al. (1988) preferences to the spatial setting. With one region-sector, this setup coincides with the textbook GHH preferences, which mute wealth effects on labor supply, making working hours only depend on within-period real wages. When $\psi = 0$, the model collapses to the standard Roy-Fréchet framework (Lagakos and Waugh, 2016; Hsieh et al., 2019) where labor is differentiated by sectors with fixed regional labor supply. Sectoral labor supply is governed by the elasticity θ, with higher θ implying greater labor mobility across sectors. In the static multi-country and multi-sector setting, Bonadio et al. (2023) model sectoral labor supply using a combination of the GHH preferences and the Roy-Fréchet framework with fixed population distributions. I extend their labor supply setup to a dynamic spatial setting with population distributions varying due to migration.

Migration. At the end of each period, households can migrate to another region, where they will work in the next period after earning labor income and making consumption decisions in the current region. They choose a region that gives the highest utility. The dynamic problems of households are

$$\mathrm{v}_{nt} = \ln U_{nt} + \max_{m \in \mathcal{N}} \left\{ \beta \mathbb{E}[\mathrm{v}_{m,t+1}] + B_{mt} - \tau_{nmt} + \eta_{mt} \right\},$$

where v_{nt} is the lifetime utility of households in region n, and $\mathbb{E}[\mathrm{v}_{m,t+1}]$ is the future lifetime utility, with the expectation taken over all future shocks. Migration frictions are non-monetary costs, measured in terms of utility. They are origin-destination specific and can be time-varying, represented by a bilateral cost matrix τ_{nmt}.

Amenities shocks B_{mt} capture non-monetary, time-varying characteristics that make regions more or less desirable to live in. When households choose to live in region m in the next period, they enjoy region m's amenities at the end of each period t, as in Balboni (2025). Amenity shocks contribute to a more stable population distribution, making it less sensitive to changes in real income.

Households receive idiosyncratic preference shocks η_{nt} over regions for each location, independently and identically distributed across households, regions, and periods. η_{mt} follows a Type-1 Extreme Value with zero means with parameter ν. Let $V_{nt} = \mathbb{E}_{\eta}[\mathrm{v}_{nt}]$, where the expectation is taken over the preference shocks. Then, V_{nt} can be expressed as:

$$V_{nt} = \ln U_{nt} + \nu \ln \sum_{m=1}^{N} \exp(\beta V_{m,t+1} + B_{mt} - \tau_{nmt})^{\frac{1}{\nu}}. \tag{4.11}$$

This implies that the value of being in region n is the sum of the current utility and option value of moving to other regions.

Shares of households who migrate from region n to m at the end of period t are

$$\mu_{nmt} = \frac{\exp\left(\beta V_{m,t+1} + B_{mt} - \tau_{nmt}\right)^{\frac{1}{\nu}}}{\sum_{m'=1}^{N} \exp\left(\beta V_{m',t+1} + B_{m't} - \tau_{nm't}\right)^{\frac{1}{\nu}}}. \tag{4.12}$$

The expression indicates that households migrate more to regions with higher expected lifetime utility net of amenities and migration frictions, with the migration elasticity $1/\nu$. The migration elasticity governs how sensitive migration flows are to changes in expected lifetime utilities, with lower values corresponding to more persistent location choices. Population is a state variable evolving as

$$L_{n,t+1} = \sum_{m=1}^{N} \mu_{mnt} L_{mt}. \tag{4.13}$$

4.1.4 General Equilibrium

Market clearing. Goods market clearing requires that

$$\mathrm{GO}_{njt} = \sum_{m=1}^{N} \pi_{mnt}^{j} \left[\sum_{k=1}^{J} \gamma_k^j \mathrm{GO}_{mkt} + \alpha_j (1+\iota_t) W_{mt} h_{mt} L_{mt} \right] + \mathrm{EX}_{njt}, \tag{4.14}$$

where GO_{njt} is region-sector nj gross output. The term inside the brackets is region m's total expenditures on sector j goods. The labor market clearing condition is

$$W_{njt} H_{njt} = \gamma_j^H \mathrm{GO}_{njt}. \tag{4.15}$$

Real GDP. Measured real GDP is calculated based on real value-added and sectoral PPIs.[9] I use value-added shares to aggregate changes in real GDP at the aggregate and regional levels following Caliendo et al. (2018). Appendix C.1 provides detailed expressions for real GDP.

Shocks. There are six time-varying exogenous shocks to the fundamentals, $\mathbf{\Psi}_t = \{A_{njt}, E_{njt}, P_{jt}^F, D_{jt}^F, 1+\iota_t, B_{nt}\}_{n=1,j=1}^{N,J}$, and shocks to migration frictions, $\boldsymbol{\tau}_t = \{\tau_{nmt}\}_{n,m=1}^{N}$. Shocks transmit to other region-sectors through trade and migration linkages.

Equilibrium. Given $\{L_{nt}\}_{n=1}^{N}$, $\mathbf{\Psi}_t$, and $\boldsymbol{\tau}_t$, allocation in each period is determined as in static trade and spatial models. Population evolves according to the optimal migration decisions of households. I formally define the equilibrium as follows:

Definition 1. *Given $\{\mathbf{\Psi}_t\}_{t=t_0}^{\infty}$, $\{\boldsymbol{\tau}_t\}_{t=t_0}^{\infty}$, and initial allocations of the state variable $\{L_{nt_0}\}_{n=1}^{N}$, the competitive equilibrium of the model is the set of population, sectoral allocation of workers, sectoral labor supply, working hours, wages, and expected lifetime utilities $\{L_{nt}, \lambda_{njt}, H_{njt}, h_{nt}, W_{njt}, V_{nt}\}_{n=1,j=1,t=t_0}^{N,J,\infty}$ that satisfies the following conditions for each region-sector nj and period t: (i) Given $\{W_{njt}\}_{n=1,j=1}^{N,J}$, households maximize their utility and optimally allocate their workers across different sectors; (ii) $\{V_{nt}\}_{n=1}^{N}$ satisfies equation (4.11); (iii) $\{L_{nt}\}_{n=1}^{N}$ evolves according to equation (4.13); and (iv) goods and labor market clearing conditions are satisfied according to equations (4.14) and (4.15).*

4.1.5 Taking Stock

Crisis and shocks. The crisis is modeled as five time-varying exogenous shocks in a reduced-form fashion, $\mathbf{\Psi}_t^{\text{crisis}} = \{A_{njt}, E_{njt}, D_{jt}^F, P_{jt}^F, 1+\iota_t\} \subset \mathbf{\Psi}_t$. These shocks capture key features of emerging

[9] PPIs are constructed to mirror statistical agencies' practices (Burstein and Cravino, 2015; Choi et al., 2025).

market economies after crises. Lower A_{njt} represents large drops in TFP and output, previously documented in the literature (e.g. Meza and Quintin, 2007; Pratap and Urrutia, 2012; Queralto, 2020). A_{njt} may capture both negative physical productivity and financial shocks. Appendix C.2.1 illustrates this using a model based on working capital constraints, where balance sheet effects appear as A_{njt}.

E_{njt} relates to various shocks to region-sector labor supply curves during the crisis, such as region-sector specific labor market frictions. In many classes of trade models with labor market frictions such as downward nominal rigidities (Rodriguez-Clare et al., 2022) or matching frictions (Kim and Vogel, 2021), employment rates appear in the position of E_{njt} in equations (4.8) and (4.9), with higher region-sector frictions making employment rates lower. This is formally shown in Appendix C.2.2. Relatedly, Drenik (2016) and Blanco et al. (2025) document heterogeneity in downward nominal rigidities across sectors driven by differences in unionization. Such heterogeneity may manifest as labor supply shocks in the model.

Higher D^F_{jt} and P^F_{jt} explain large export expansions and import collapses due to depreciations after crises, as modeled in Gopinath and Neiman (2014) and Blaum (2024). Finally, $1 + \iota_t$ captures rapid declines in trade deficits after crises (Kehoe and Ruhl, 2009).

Labor reallocation. In response to the crisis-related shocks, total labor supply in efficiency units adjusts across region-sectors based on household sectoral labor supply, working hours, and migration decisions. These decisions are governed by three elasticities, θ, ψ, and $1/\nu$, respectively:

$$H_{njt} = E_{njt} \times \underbrace{\left(\frac{W_{njt}}{W_{nt}}\right)^{\theta-1}}_{\substack{\theta\,:\,\text{Sectoral reallocation}\\ \text{within regions}}} \times \underbrace{\left(\frac{W_{nt}}{P_{nt}}\right)^{\psi}}_{\psi\,:\,\text{Working hours}} \times \underbrace{\sum_{m=1}^{N} \mu_{nm,t-1} L_{m,t-1}}_{1/\nu\,:\,\text{Migration}}.$$

Lower migration frictions lead to more flexible reallocation of labor across regions through the migration channel.

4.2 Counterfactual

I conduct counterfactual analysis to examine how the economy would have adjusted differently to the same shocks with varying levels of migration mobility. Using the dynamic hat algebra developed by Caliendo et al. (2019), I solve the model in changes. This approach requires information on the initial allocation in 1997, structural parameters, and shocks in changes:

$$\{\mathbf{\Psi}_t\}_{t=98}^{\infty} = \{\hat{A}_{njt}, \hat{E}_{njt}, \hat{D}^F_{jt}, \hat{P}^F_{jt}, \widehat{1+\iota_t}, \hat{b}_{nt}\}_{t=98}^{\infty},$$

where $\hat{b}_{nt} = \exp(B_{nt} - B_{n,t-1})$, and counterfactual migration frictions shocks $\{\hat{m}_{mnt}\}_{t=97}^{\infty}$, with $\hat{m}_{mnt} = \exp(\tau_{mnt} - \tau_{mn,t-1})$.

In the baseline economy, there are no changes in migration frictions ($\hat{m}_{mnt} = 1$, $\forall t$) and only exogenous shocks $\hat{\mathbf{\Psi}}_t$ are fed into the initial allocation. Counterfactual economies with different mobility levels are constructed by feeding both the exogenous and migration friction shocks. I consider temporary changes in migration frictions lasting up to 4 years, returning to original levels 5 years after the crisis. These temporary changes reflect realistic policy options, such as promoting rural-to-urban migration during the crisis. 1 year before the crisis in 1997, the temporary shocks occur unexpectedly, influencing households' migration decisions before the anticipated crisis in 1998. The friction levels remain constant between 1998-2001 and then revert to their original levels in 2002. Specifically, $\hat{m}^c_{mn,97}$ in 1997, $\hat{m}^c_{nmt} = 1$ for $t \in \{98, 99, 00, 01\}$, and $\hat{m}^c_{nm,02} = 1/\hat{m}^c_{nm,97}$.

I consider four counterfactual mobility levels: no-mobility, full-mobility, common 10% reductions, and directional 10% reductions.

- No- and Full-Mobility: $\hat{m}^c_{nm,97} = C, \forall n, m \in \mathcal{N}$ for some large (no-mobility) and small (full-mobility) numbers C, respectively. Full-mobility resembles a setting of canonical tradable-nontradable models without reallocation costs in international macro literature (e.g. Uribe and Schmitt-Grohé, 2017).
- Common 10% reductions: $\hat{m}^c_{nm,97} = 0.90$ for all pairs, reflecting empirically plausible reductions inferred from observed migration shares (Head and Ries, 2001; Monte et al., 2018).[10] Between 1997-2007, the median reduction was 10% among inferred frictions.[11]
- Directional 10% reductions: Applied only to migration flows to destinations with higher top 5 employment shares than origins: $\hat{m}^c_{nm,97} = 0.90$ for pairs that satisfy $\text{Empsh}^{\text{top5}}_{m,94} > \text{Empsh}^{\text{top5}}_{n,94}$.

4.3 Taking the Model to the Data

This section describes the calibration, summarized in Table 4, with details in Appendix C.

4.3.1 Structural Parameters

Discount factor. I set the 1-year discount factor β to the conventional value of 0.96.

Elasticities. I set the trade elasticity to $\sigma - 1 = 4$ (Costinot and Rodríguez-Clare, 2014). I calibrate $\theta = 1.5$ based on estimates from recent literature.[12] I calibrate $\psi = 0.75$ following Chetty et al. (2011).

I can derive an estimable specification from the quantitative model and estimate it in long-

[10] Under the symmetry ($\tau_{mnt} = \tau_{nmt}, \forall n, m \in \mathcal{N}$), migration frictions can be inferred from observed migration shares: $\exp(\tau_{nmt})^{\frac{1}{\nu}} = (\frac{\mu_{nmt}\mu_{mnt}}{\mu_{nnt}\mu_{mmt}})^{-0.5}$. These inferred frictions are highly correlated with observed proxies such as distance and the regional conflict indices (Appendix Figure C11).

[11] This 10% reduction is also consistent with Monte et al. (2018), who find a 12% decline in commuting frictions between 1990 and 2010 in the US. Between 1997 and 2007, South Korea experienced a 32% increase in paved public roads and a 235% increase in highways, which may have contributed to reductions in migration frictions.

[12] Burstein et al. (2019) report values of 1.26–1.81; Hsieh et al. (2019), 1.5–2.6; Lee (2020), 1.05–1.47; and Galle et al. (2023), 2.

Table 4: Summary of Calibration

Parameters	Value	Description	Target
Elasticities			
$1/\nu$	0.29	Migration elast.	IV estimate, equation (4.16)
ψ	0.75	Agg. labor supply elast.	Chetty et al. (2011)
θ	1.5	Sectoral labor supply elast.	Galle et al. (2023)
σ	5	Trade elast.	Costinot and Rodríguez-Clare (2014)
Geographic frictions			
$\{\xi_j\}$	0.26, 0.4	Trade costs	Monte et al. (2018), Eckert (2019)
Shocks			
$\{\hat{A}_{njt}\}$		Productivity shocks	Gross output, PPI, real GDP growth
$\{\hat{E}_{njt}\}$		Labor productivity shocks	Emp. shares
$\{\hat{D}^F_{jt}\}$		Foreign demand shocks	Sectoral exports
$\{\hat{P}^F_{jt}\}$		Import price shocks	Sectoral imports
$\{\widehat{1+\iota_t}\}$		Trade deficits	Trade deficits
$\{\hat{b}_{nt}\}$		Amenity shocks	Regional pop.
Preference & Production			
β	0.96	Discount factor	Literature
$\{\alpha_j\}$		Final consumption shares	IO table
$\{\gamma^H_j, \gamma^k_j\}$		IO coeff.	IO table

differences between 1997-2000 to recover migration elasticity $1/\nu$ (Artuc et al., 2010)[13]:

$$\Delta \ln \frac{\mu_{nmt}}{\mu_{nnt}} = \frac{\beta(1+\psi)}{\nu}\Delta \ln \frac{W_{m,t+1}/P_{m,t+1}}{W_{n,t+1}/P_{n,t+1}} + \beta\Delta \ln \frac{\mu_{nm,t+1}}{\mu_{mm,t+1}} + \mathbf{X}'_{nmt}\gamma + \tilde{\varepsilon}_{nmt}. \tag{4.16}$$

Any time-invariant components of migration frictions or differences in amenities between two regions are differenced out. $\tilde{\varepsilon}_{nmt}$ is the structural error term that is a function of time-varying components of migration frictions and amenities. Depending on specifications, I control for observables $\mathbf{X}_{nmt}$ related to amenities and migration frictions, including the three proxies for migration frictions and the changes in amenities and log housing price between 1995-2000, which are included in the migration analysis.

I proxy W_{nt} by dividing region n's total value-added by its total employment. Regional price levels P_{nt} are obtained from the regional CPI data.[14] The Korean statistical agency reports CPI only for the selected regions. Therefore, following Moretti (2017), I impute CPI data for regions with missing

[13] In the regression model, current migration flows reflect the future values of expected real income and option values, where the future migration flows are the sufficient statistics for the option values. Conditioning on the option values, variation in real income differences across regions identifies the migration elasticity. See Appendix C.3 for more details on the derivation of the regression model from the theoretical framework

[14] One concern with using CPI is that it is comparable across times within regions but not cross-sectionally across regions, because the CPI is normalized to be one in the base year. However, with the log utility function, differences in unobservable price levels of the base year between two regions are differenced out.

Table 5: Migration Elasticity

	Baseline			Dist. ≥ 200km	Alt. cluster
	OLS	IV			
	(1)	(2)	(3)	(4)	(5)
	Panel A. Second Stage				
$\Delta \ln \frac{W_{m,t+1}/P_{m,t+1}}{W_{n,t+1}/P_{n,t+1}}$	0.14	0.59*	0.58*	0.61*	0.58***
	(0.13)	(0.34)	(0.33)	(0.33)	(0.13)
KP-F		15.97	15.63	16.08	476.85
AR-p		0.05	0.04	0.04	0.00
	Panel B. First Stage				
IV_{nmt}		0.19***	0.21***	0.22***	0.21***
		(0.05)	(0.05)	(0.05)	(0.01)
Controls			✓	✓	✓
N	2,914	2,914	2,914	1,852	2,914

Notes. Standard errors are in parenthesis. *: $p < 0.1$; **: $p < 0.05$; ***: $p < 0.01$. Standard errors are two-way clustered at the origin and destination levels in columns 1-4 and clustered at the pair level in column 5. Panel A reports the OLS and IV estimates of equation (4.16). Panel B reports the first stage results of the IV estimates. Columns 3-5 include the initial differences in industrial composition, log bilateral distance, index for regional conflicts, log housing price, and amenity index of origins and destinations. KP-F is the Kleibergen-Paap F-statistics. AR-p is p-value associated with the Anderson-Rubin test statistics, corresponding to the null hypothesis that the coefficient of $\Delta \ln \frac{W_{m,t+1}/P_{m,t+1}}{W_{n,t+1}/P_{n,t+1}}$ is zero.

information using housing price data that are available for all regions. Out of 54 regions, the regional CPI data is available for 32 regions and CPIs of the remaining 22 regions are imputed.

Because differences in real wages can be correlated with shocks to amenities and migration frictions shocks, the OLS estimates may suffer from the endogeneity problem. Therefore, I estimate equation (4.16) using the following IV:

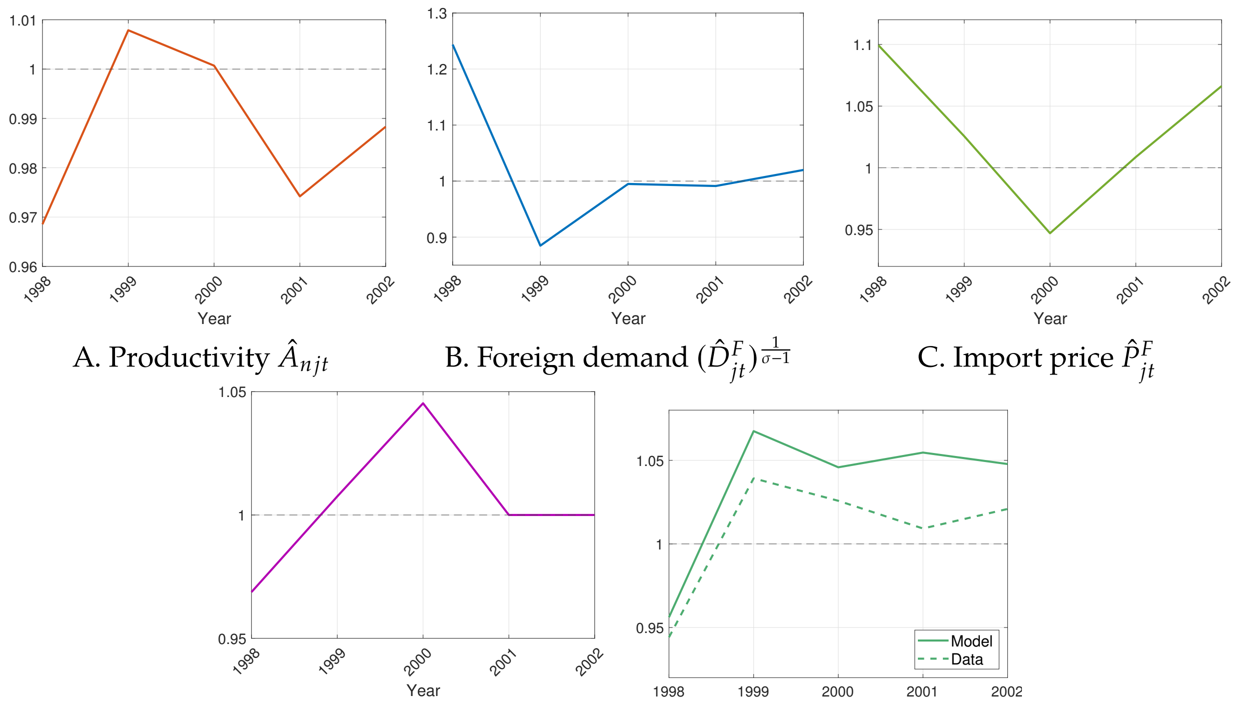
$$\text{IV}_{nmt} = (\text{Empsh}^{\text{top5}}_{m,94} - \text{Empsh}^{\text{top5}}_{n,94}). \tag{4.17}$$

The identifying assumption of the IV holds when migration friction and amenity shocks are uncorrelated with the initial differences in the top 5 employment shares, conditional on the covariates.

Table 5 reports the regression results. The IV estimate is statistically significant at the 10% level. With the assumed values for the discount factor and aggregate labor supply elasticity, this estimate gives a value of $1/\nu$ around 0.3. The magnitude is consistent with previous papers.[15] The estimates remain stable with the additional controls. The first stage is strong, with Kleibergen-Paap F-statistics (KP-F) around 16, above the rule of thumb value 10, rejecting the null hypothesis of weak instrument using the test proposed by Olea and Pflueger (2013). The estimates are also significant at the 5% level based on the Anderson-Rubin test, which is robust to weak instruments. The results remain robust

[15] Caliendo et al. (2021) report a value of 0.5 annually, while Caliendo et al. (2019) report 0.2 quarterly.

Figure 4: Recovered Shocks and Labor Supply



A. Productivity $\hat{A}_{njt}$ B. Foreign demand $(\hat{D}^F_{jt})^{\frac{1}{\sigma-1}}$ C. Import price $\hat{P}^F_{jt}$

D. Deficit $\widehat{1+\iota_t}$ E. Labor supply $\hat{H}_{njt}$

Notes. The figure presents the evolution of the shocks. Panels A, B, and C plot the weighted average of the productivity, foreign demand, and import price shocks, where the weights are given by region-sector gross output, sectoral imports, and sectoral exports, respectively. Panel D plots the ratio of deficits to GDP. Panel E plots employment-weighted labor supply (equation (4.9)).

to excluding migration flows within 200km (column 4) and alternative clustering at the pair level (column 5).

Trade costs. I parametrize internal trade costs as a function of physical distance: $d^j_{nm} = (\text{Dist}_{nm})^{\xi_j}$, where Dist_{nm} is distance between regions and ξ_j are parameters varying across sectors. I set $(\sigma-1)\xi_j$ to be 1.29 for commodity and manufacturing sectors and 2 for service sectors based on the estimates from Monte et al. (2018) and Eckert (2019). I parametrize international trade costs as $d^j_{Fn} = (\text{PDist}_n)^{\xi_j}$, where PDist_n is region n's minimum distance to port. International trade costs that are common across regions are not separately identifiable from P^F_{jt} and D^F_{jt}, so d^j_{Fn} captures the costs relative to those of regions with ports.

IO coefficients and final consumption shares. I obtain value-added shares, IO coefficients, and final consumption good shares from the WIOD.

4.3.2 Initial Allocation

I need the initial allocation of $\{\text{GO}_{njt_0}, \lambda_{njt_0}, \mu_{nm.t_0-1}, L_{nt_0}, \text{EX}_{njt_0}, \pi^j_{nmt_0}, \pi^j_{Fnt_0}\}^{N,J}_{n,m=1,j=1}$ to apply the dynamic hat algebra. $\{\text{GO}_{njt_0}, \lambda_{njt_0}, L_{nt_0}, \mu_{nm,t_0-1}\}^{N,J}_{n,m=1,j=1}$ is obtained directly from the data. However, I do not have region-sector level information on $\{\text{EX}_{njt_0}, \pi^j_{Fnt_0}, \pi^j_{nmt_0}\}^{N,J}_{n,m=1,j=1}$. I indirectly infer these variables from sectoral exports and imports, region-sector gross output, and the gravity structure of trade under the parametrized trade costs. Under the gravity structure, there exists a unique set of trade shares that rationalize observed region-sector gross output and sectoral exports and imports. Thus, I can infer these variables by solving the gravity structure given the available data, detailed in Appendix C.6.1.

4.3.3 Recovering Shocks

I assume that the model reaches the steady state for a sufficiently large period $T = 2072$. After 2002, I set the shocks $\hat{\mathbf{\Psi}}_t$ to start converging to their 1997 original level in 2003 and reach that level 30 years after the crisis. More specifically, given the values of $\{\hat{\mathbf{\Psi}}_t\}_{t=98}^{02}$, the shocks evolve as

$$\hat{\mathbf{\Psi}}_t = 1/\Big(\prod_{\tau=98}^{02} \hat{\mathbf{\Psi}}_\tau\Big)^{\frac{1}{25}}, \quad \forall t \in \{03, \ldots, 28\} \quad \text{and} \quad \hat{\mathbf{\Psi}}_t = 1, \quad \forall t \in \{29, \ldots, T\}.$$

Under the assumed shock process, I recover the shocks between 1997-2002, $\{\hat{\mathbf{\Psi}}_t\}_{t=98}^{02}$, by fitting the model to the data, while taking into account the fact that agents have perfect foresight regarding the sequence of the shocks. The model is fitted to sectoral gross output distributions across regions, sectoral PPIs, aggregate real GDP growth, region-sector employment shares, sectoral import shares, sectoral exports, and regional population between 1997-2002, detailed in Appendix C.6.2.[16]

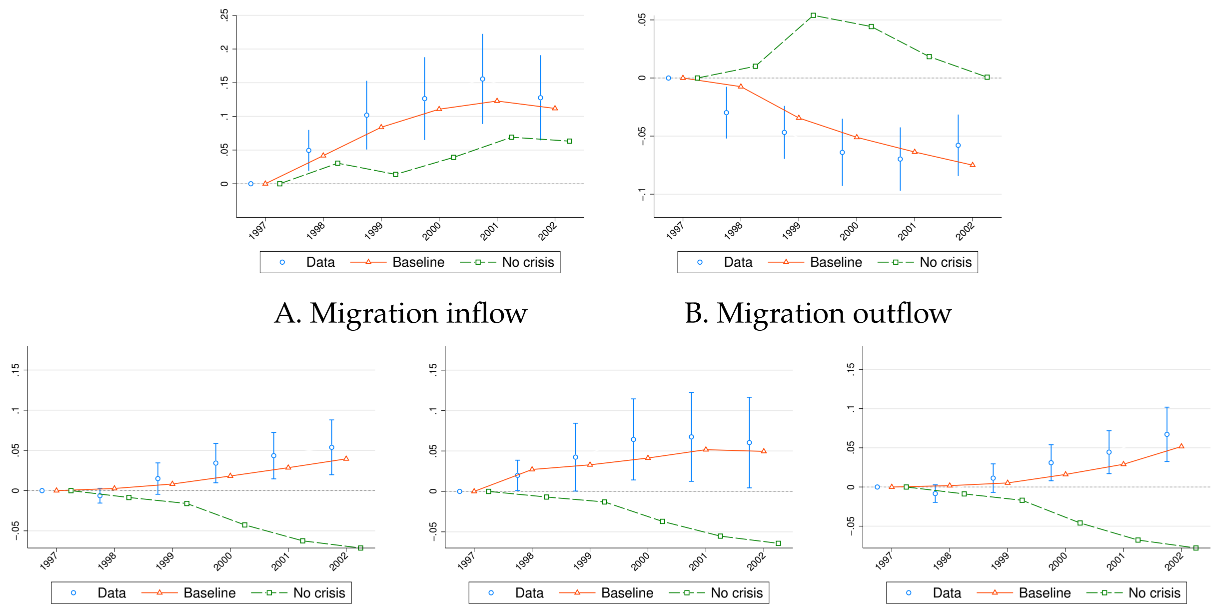
Although all shocks are jointly identified, some variables are more relevant to particular shocks. $\hat{A}_{njt}$ are mainly identified from gross output, PPIs, and aggregate real GDP growth. Regional distributions of gross output identify relative $\hat{A}_{njt}$ of each region within sector-year, while PPIs and aggregate real GDP growth identify the absolute levels. Conditioning on the identified $\hat{A}_{njt}$, region-sector employment shares identify $\hat{E}_{njt}$, and sectoral import shares and exports identify $\hat{P}^F_{jt}$ and $\hat{D}^F_{jt}$, respectively.[17] Without variation in $\hat{E}_{njt}$, there is a one-to-one mapping between gross output and employment shares within regions, which is not the case in the data. Introducing $\hat{E}_{njt}$ allows the model to account for differential variation in both gross output and employment shares. Finally, the exogenous trade deficits $\widehat{1+\iota_t}$ are directly taken from the data. Population distributions identify $\hat{b}_{nt}$ as residuals that cannot be explained by real income changes up to normalization.

Figure 4 illustrates the evolution of the recovered shocks and labor supply. Panels A, B, and C present the weighted averages of productivity, foreign demand, and import price shocks, with weights assigned based on region-sector gross output, sectoral imports, and sectoral exports, respectively. In the crisis year, on average, productivity decreased by 3%, foreign demand increased by 24%, and the average import prices rose by 10% relative to the previous year. Panel D presents deficit shocks, which declined by 3% in 1998 due to export expansions and collapses in imports.

[16] I detrend sectoral PPIs and aggregate real GDP using the Hodrick-Prescott filter to isolate the cyclical component of the data from the trend components. I set the smoothing parameter to 100.

[17] Conditional on $\hat{A}_{njt}$, $\hat{E}_{njt}$ are identified upto normalization, so $\hat{E}_{njt}$ of the reference sector is set to 1 for all regions and periods.

Figure 5: Goodness of Fit. Event Study. Migration and Employment Responses to the Crisis



A. Migration inflow B. Migration outflow

C. Total emp. D. Top 5 emp. E. Non-top 5 emp.

Notes. This figure compares the estimates of the migration and employment event-study analysis from the actual and model-generated data. In Panels A-E, the dependent variables are log migration inflows, migration outflows, total employment, top 5 employment, non-top 5 employment, respectively. The blue circles represent the estimated event study coefficients from the data, with 95% confidence intervals (Figures 2 and 3). The triangle and rectangular represent the coefficients from the model-generated data under the baseline and no-crisis scenarios, respectively.

Labor supply shocks are normalized within each region, with the absolute level having no specific meaning. Therefore, instead of labor supply shocks, Panel E reports the weighted average of labor supply $\hat{H}_{njt}$ across region-sectors, where weights are given by each region-sector's employment (equation (4.9)). The average labor supply dropped by 4.5% in 1998, capturing the 5% decline in aggregate working hours observed in the KLEMS dataset. The calibration procedure does not target aggregate working hours, so this can be viewed as a non-targeted moment.

5. Quantitative Results

5.1 Model Fit and Validation

Before turning to the counterfactual analysis, I evaluate performance of the model by comparing the long-difference and event-study estimates from the model-generated and actual data, reported in Panel A of Table 6. The long-difference estimates from the model-generated data are within the standard errors of those from the actual data. The model also captures the dynamic path of the event study coefficients (Figure 5). I simulate a no-crisis scenario by turning off all the crisis-related shock ($\hat{\boldsymbol{\Psi}}_t^{\text{crisis}} = 1$) while keeping the amenity shock. The model-generated data fails to replicate the estimates in this scenario.

Next, I examine the role of individual shocks in replicating the estimates. I shut down specific

Table 6: Goodness of Fit. OLS Long-Difference. Migration and Employment Responses to the Crisis

Dep.	Migration inflow	Migration outflow	Total emp.	Top 5 emp.	Non-top 5 emp.
	(1)	(2)	(3)	(4)	(5)
	Panel A. Actual data & Mode-generated data				
Data	0.09**	−0.04***	0.03**	0.06*	0.03**
	(0.03)	(0.01)	(0.01)	(0.03)	(0.01)
Model	0.08***	−0.03***	0.03**	0.05**	0.02
	(0.03)	(0.01)	(0.01)	(0.02)	(0.01)
	Panel B. Alternative scenarios				
No crisis	0.07*	0.02	0.00	0.00	−0.00
	(0.03)	(0.02)	(0.01)	(0.01)	(0.02)
Shutting down one shock					
Labor supply shock	0.05	0.06**	−0.02	0.02	−0.04*
	(0.04)	(0.03)	(0.02)	(0.02)	(0.02)
Productivity shock	0.09***	−0.07***	0.04***	0.02	0.04**
	(0.03)	(0.02)	(0.01)	(0.03)	(0.02)
Trade-related shocks	0.08***	−0.04***	0.03**	0.05**	0.03**
	(0.03)	(0.01)	(0.01)	(0.02)	(0.01)
Feeding in one shock					
Labor supply shock	0.02	−0.09**	0.06**	0.04	0.08***
	(0.03)	(0.04)	(0.02)	(0.03)	(0.03)
Productivity shock	−0.02**	0.04***	0.01	0.05	−0.01
	(0.01)	(0.01)	(0.01)	(0.03)	(0.01)
Trade-related shocks	−0.01**	0.00	0.02**	0.02*	0.01
	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)

Notes. This table presents the estimated coefficients of the Bartik shock of equations (3.1) and (3.4) with the full set of the additional controls (Appendix B.1), respectively. Standard errors are reported in parenthesis. *: $p < 0.1$; **: $p < 0.05$; ***: $p < 0.01$. In columns 1-5, the dependent variables are changes in log migration inflows, migration outflows, total employment, top 5 employment, non-top 5 employment between 1997-2000, respectively. Panel A reports the coefficients estimated from the model-generated and actual data. Panels B reports the estimates from the model-generated data under the alternative sequences of the shocks.

shocks one at a time, keeping the remaining shocks the same, and compare the moments from the model-generated data to those from the actual data. I shut down productivity ($\hat{A}_{njt}$), labor supply ($\hat{E}_{njt}$), or trade-related shocks ($\hat{D}^F_{jt}$, $\hat{P}^F_{jt}$, and $\widehat{1+\iota_t}$) individually. Additionally, I consider feeding in only a set of specific shocks at a time while turning off the remaining shocks. In these exercises, each shock is treated as orthogonal to the others.

Labor supply shocks are key to replicating the two findings. When shutting down labor supply shocks, the model cannot replicate the two moments (Panel B). When only labor supply shocks are fed in, the model can replicate qualitatively similar but quantitatively larger moments for migration outflows and employment-related variables. Similar patterns are observed for the event study coefficients when shutting off or feeding in (Appendix Figures C12 and C13). These results emphasize the importance of the labor supply side for understanding the dynamics of employment and migration after the crisis. Productivity and trade-related shocks play more limited roles.

Table 7: Outflow Migration Rate

	Baseline	No-mobility	Free-mobility	Decrease med. (common)	Decrease med. (directional)
	(1)	(2)	(3)	(4)	(5)
Avg. 1998-2001 (%)	8.39	0	90.06	9.12	8.79

Notes. The table reports the average outflow migration rates between 1998-2001 of the baseline and counterfactual economies with different migration mobility levels.

Table 8: Sectoral Reallocation of Labor. Aggregate Top 5 Employment Share

	Baseline	No-mobility	Full-mobility	Decrease med. (common)	Decrease med. (directional)
	(1)	(2)	(3)	(4)	(5)
Avg. 1998-2001 (%)	18.17	18.10	18.42	18.17	18.24

Notes. The table reports the average aggregate employment shares in the top 5 sectors between 1998-2001 of the baseline and counterfactual economies with different migration mobility levels.

5.2 Counterfactual Analysis

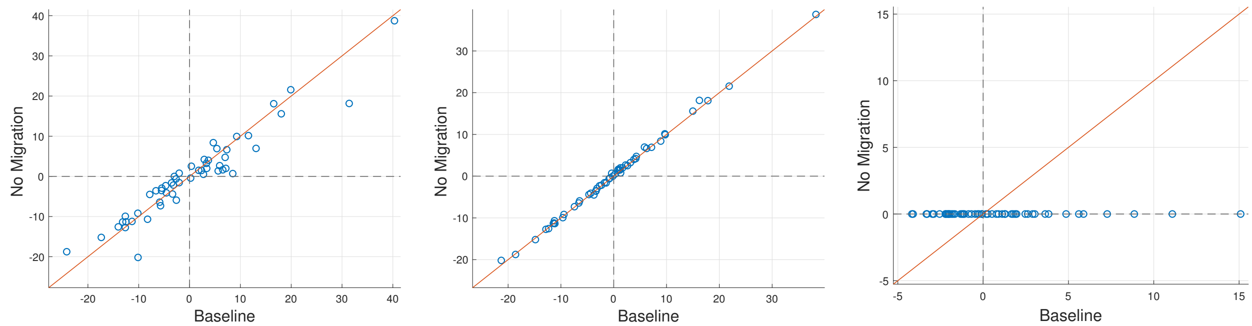
5.2.1 Migration Mobility and Post-Crisis Recovery

Next, I quantitatively explore how migration contributed to the post-crisis recovery under the baseline and counterfactuals with different levels of mobility. Table 7 reports the average outflow migration rates ($\sum_m \mu_{nmt}$) between 1998-2001. In the baseline, the average rate was 8.39%. In the extreme full-mobility counterfactual, the average rate was 90.1%. The common and directional reductions modestly increased the rate by 0.7 percentage point and 0.4 percentage point compared to the baseline.

Because of the imperfect mobility of labor and heterogeneous industrial composition, the desired amounts of sectoral reallocation into the top 5 sectors may not be achieved after the crisis. I examine relationships between levels of mobility and aggregate employment shares in the top 5 sectors. Table 8 reports the average top 5 employment shares between 1998-2001. Higher mobility was associated with larger top 5 shares. Changes in top 5 employment can result from changes in either employment shares within regions or population adjustments, with most of the changes explained by the latter. Figure 6 compares each region's changes in top 5 employment, top 5 employment shares, and population during 1997-2000 between the baseline mobility and no-mobility counterfactual on the x- and y-axes, respectively. Changes in population account for most of variation in top 5 employment, with within-region changes in employment shares explaining only about 1% of the total variation in top 5 employment.

Panel A of Table 9 shows that greater sectoral reallocation into the top 5 sectors translated into higher aggregate real GDP growth $\hat{Y}_t^r$. With the baseline mobility, real GDP dropped by 3.47% in 2001 compared to 1997, equivalent to an annual growth rate of -0.88% between 1998-2001. Higher mobility levels were associated with smaller declines in aggregate real GDP. In the full-mobility counterfactual,

Figure 6: Regional Effects. Baseline Mobility versus No-Mobility



A. Δ Top 5 emp (%) B. Δ Top 5 emp shares (%) C. Δ Pop. (%)

Notes. Panels A, B, and C illustrate changes in regional top 5 employment, top 5 employment shares, and population between 1997-2000 for both the baseline and no-mobility counterfactual. Each dot represents a region, with the x- and y-axes corresponding to the baseline and no-mobility counterfactual. The red line represents the 45-degree line.

Table 9: Real GDP Growth

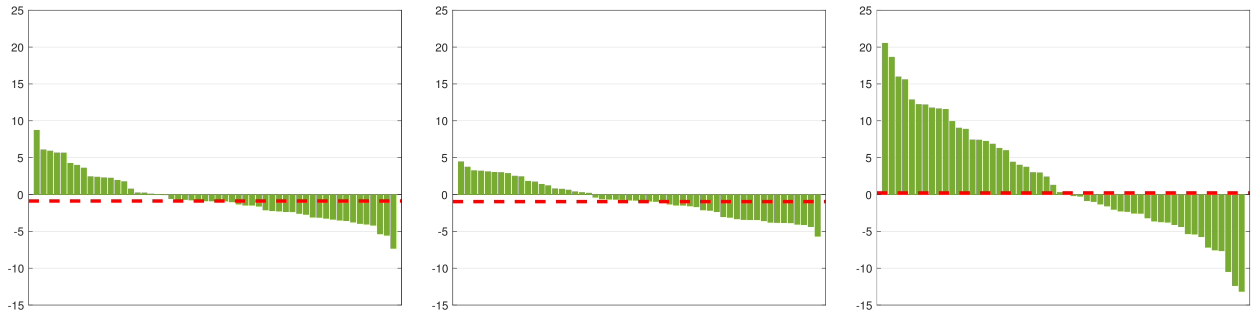
	Baseline	No-mobility	Full-mobility	Decrease med. (common)	Decrease med. (directional)
Years since the crisis	(1)	(2)	(3)	(4)	(5)
Panel A. Crisis					
Aggregate					
Cumulative growth ($\prod_{\tau=98}^{01} Y_\tau^r$) (%)	−3.47	−3.79	0.89	−3.44	−3.32
Avg. annual growth, ($\prod_{\tau=98}^{01} Y_\tau^r)^{\frac{1}{5}}$ (%)	−0.88	−0.96	0.22	−0.87	−0.84
Regional					
Std. $\log\left(\prod_{\tau=98}^{01} \hat{Y}_{n\tau}^r\right)$	0.13	0.10	0.31	0.13	0.14
$\hat{\beta}^{\text{GDP}}$	0.09***	0.04***	0.15***	0.10***	0.11***
	(0.02)	(0.01)	(0.04)	(0.02)	(0.02)
Panel B. No crisis					
Aggregate					
Cumulative growth ($\prod_{\tau=98}^{01} Y_\tau^r$) (%)	0.32	0.30	2.44	0.22	0.31
Avg. annual growth, ($\prod_{\tau=98}^{01} Y_\tau^r)^{\frac{1}{5}}$ (%)	0.08	0.08	0.61	0.05	0.08
Regional					
Std. $\log\left(\prod_{\tau=98}^{01} \hat{Y}_{n\tau}^r\right)$	0.09	0.00	0.28	0.10	0.11
$\hat{\beta}^{\text{GDP}}$	0.04***	0.00	0.07*	0.05**	0.06***
	(0.02)	(0.00)	(0.04)	(0.02)	(0.02)

Notes. Panels A and B report the counterfactual results on aggregate and regional real GDP growth under the crisis and no-crisis scenarios, respectively. Robust standard errors of $\hat{\beta}^{\text{GDP}}$ are reported in parenthesis. *: $p < 0.1$; **: $p < 0.05$; ***: $p < 0.01$. See Appendix C.3 for more details on the aggregation of real GDP.

cumulative growth between 1998-2001 exceeded the baseline by 4.36 percentage points. Notably, the disparity between the baseline and full-mobility outcomes surpassed that between the baseline and no-mobility outcomes, reflecting the proximity of baseline mobility levels to no-mobility rather than full-mobility.

Moreover, the directional reductions led to higher aggregate real GDP growth compared to the common reductions (−3.32% vs. −3.44%), despite lower mobility rates with the former (8.79% vs.

Figure 7: Migration Mobility and Regional Real GDP Growth after the Crisis



Average regional real GDP growth rates 1998-2001 (%)

A. Baseline B. No-mobility C. Free-mobility

Notes. Panels A, B, and C illustrate the geometric average of each region's real GDP growth between 1998-2001 under different mobility levels, where the red dashed lines represent the average aggregate real GDP growth between 1998-2001.

9.12%). This suggests that the effectiveness of migration policies to boost aggregate real GDP depends on both magnitude and direction of reductions. If policymakers aim to boost real GDP, directional reductions can achieve this goal more effectively with less migration compared to common reductions.

Higher mobility rates were associated with larger dispersion in real GDP growth at the regional level, as indicated by standard deviations of regional cumulative growth. When regressing regional cumulative real GDP growth between 1998-2001 on top 5 employment shares: $\ln\left(\prod_{\tau=98}^{01} \hat{Y}_{n\tau}^{r}\right) = \alpha + \beta^{\text{GDP}}\text{Empsh}_{n,94}^{\text{topt}} + \varepsilon_n$, higher mobility had higher estimates for β^{GDP}, implying that larger dispersion is driven by increased migration inflows into regions specializing in the top 5 sectors. Larger migration inflows not only increased production in the top 5 sectors but also in other sectors by increasing demand and lowering production costs across all sectors through IO linkages. Consequently, higher mobility levels led to production becoming more concentrated in a few regions and regional adjustments becoming more responsive to the crisis, as graphically illustrated in Figure 7.

GDP gains from higher mobility were larger during post-crisis turbulent times compared to normal times without the crisis, simulated by turning off the crisis-related shocks ($\hat{\mathbf{\Psi}}_t^{\text{crisis}} = 1$). In Panel B of the no-crisis scenario, full-mobility results in only 2.12 percentage points higher aggregate GDP growth rates compared to the baseline mobility. The increase in GDP growth rates under full-mobility is about 200% larger during the turbulent times because heterogeneous shocks at the region-sector level, induced by the crisis, make the gains from mobility larger. Additionally, because the top 5 sectors do not experience larger expansions during normal times, regions specializing in these sectors experience lower migration inflows and GDP growth, as indicated by the lower magnitude of estimated $\hat{\beta}^{\text{GDP}}$ under the no-crisis scenario compared to the baseline scenario with the crisis.

While the framework does not explicitly incorporate monetary costs of increasing mobility, the calculated GDP effects provide useful bounds to assess whether policies aimed at improving mobility are worth implementing. For example, common and directional reductions in migration frictions increased real GDP by 64 and 319 millions USD per year (in 2011 USD) compared to the baseline. In these scenarios, the average annual outflow rates were 0.73 percentage point and 0.4 percentage point higher than the baseline, translating to additional 188,000 and 103,000 people moving per year, respectively. If the costs of implementing these two scenarios were lower than \$340 and \$3,090 per additional person moving, respectively, they would yield grater benefits than costs.

5.2.2 Robustness

Permanent changes in migration frictions. Instead of temporarily changing migration frictions, Panel A of Appendix Table C9 considers permanent reductions, which may reflect, for example, effects of upgrading transportation infrastructure. The GDP results remain quantitatively similar.

No amenity shocks. In Panel B of Appendix Table C9, I re-calibrate the shocks assuming no amenity shocks and not targeting population. Population distributions swing larger without amenity shocks but the magnitude remains similar.

Capital accumulation. In Panel C of Appendix Table C9, I incorporate dynamic investment in capital following Kleinman et al. (2021), where labor shares of value-added are set to 0.66. See Appendix C.7 for more details on the extended model. The counterfactual results are qualitatively similar but has lower magnitude, because labor plays less important roles in production and immobile capital slowly adjusts over time.

Sensitivity analysis. Appendix Table C10 assesses sensitivity of the main quantitative results for alternative parametrization. For each alternative parametrization, the model is re-calibrated to fit the data. I consider higher and lower values of σ, $1/\nu$, θ, and ψ. Higher σ values increase the magnitude as regional varieties become more substitutable, enhancing migration's role (Panel A). Higher $1/\nu$ values also increase the magnitude by making migration flows more sensitive to real income changes (Panel B). Conversely, higher θ values decrease the magnitude as greater sectoral reallocation reduces migration's role (Panel C). Similarly, higher ψ values decrease the magnitude as households reduce working hours due to wage declines caused by increased labor supply from migration (Panel D).

6. Conclusion

This paper studies how internal migration adjusted to the South Korean crisis of 1997-1998 and its aggregate and regional consequences on the subsequent recovery. I find that people migrated more to regions specializing in sectors that drove the post-crisis recovery, leading to larger employment growth in these regions. Using the model, I quantitatively find that higher mobility makes the economy adjust more resilient to the crisis and fosters the post-crisis recovery, while making production more geographically concentrated and regional adjustments more responsive. These findings suggest that tighter spatial linkages across factor markets can improve macroeconomic resilience of an economy.

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ONLINE APPENDIX
(NOT FOR PUBLICATION)

A. Data

I describe the data used for empirical and quantitative analyses.

Sector classification. I categorize sectors into 15 sectors. This grouping is reported in Table A1.

Region-sector employment. I use the Census on Establishment to construct region-sector employment shares. This dataset covers the universe of formal establishments with one or more employees except for agriculture, forestry, and fisheries businesses by individual owners and establishments related to national defense, housekeeping services, and international and foreign organizations. On average, approximately 2.9 million establishments are covered by the dataset across the sample period. The dataset has information on geographical location, sectors, and employment of establishments. I convert the Korean Sector Industry Code (KSIC) to the ISIC Rev 3. The sample in 1994 is used to construct the initial employment shares for the shift-share regressor of the empirical analysis. Figure A8 reports coverage by sector.

Region-sector gross output. In order to construct region-sector gross output, I combine the WIOD IO tables, state-sector level gross output data from the Statistics Korea, and employment information from the Census of Establishment. From the IO tables, I obtain the national-level sectoral gross output, which is allocated across states using the state-sector level gross output. Within state-sector, I allocate region-sector gross output using region-sector employment from the Census of Establishment. The allocation from state- to region-level is unlikely to produce large measurement errors, because the state-level data has the exact information on the major 7 cities which cover about 50% of total population. Each major 7 city is classified as an individual state according to the Korean administrative district. The major 7 cities are Seoul, Busan, Incheon, Gwangju, Daejeon, Ulsan, and Daegu.

Region-to-region migration flows. I construct region-to-region migration flows using internal migration and population datasets obtained from the Statistics Korea. Migration flows are calculated as total number of migrants between origins and destinations divided by lagged populations of origins. Own migrants are calculated as lagged population minus sum of migrants to other regions. I restrict the samples of populations and migration flows to people aged between 20 and 55 years to focus on the working population.

Sectoral trade data and IO tables. Sectoral trade data is obtained from the WIOD between 1995-2002. Countries except for South Korea are aggregated and classified as the Rest of the World (ROW). Trade data and IO tables in 1993 used to construct the initial sectoral export intensities, SecEX_{njt_0}, are obtained from the Bank of Korea.

Region-sector real capital stock. This information is only used for the quantitative analysis with the model extended to incorporate capital accumulation dynamics. I construct region-sector real capital stock by combining the Census of Establishment, Mining and Manufacturing Survey, WIOD Socio–Economic Accounts (WIOD-SEA), and International Monetary Fund Investment and Capital Stock Database (IMF-ICSD). I first allocate aggregate real capital stock from the IMF-ICSD using country-sector level nominal capital stock shares from the WIOD-SEA: $K_{jt} = \tilde{\omega}_{jt}^{K} \times K_t$, where K_t is the aggregate real capital stock from the IMF-ICSD and $\tilde{\omega}_{jt}^{K}$ is a share of sector j nominal capital stock to total nominal capital stock across sectors from the WIOD-SEA.

The Mining and Manufacturing Survey covers the universe of formal establishments with more than five employees in the mining and manufacturing sectors, which are a subset of the Census of Establishment. The Mining and Manufacturing Sector Survey has information on fixed assets. Using this information on fixed assets of manufacturing establishments, I calculate region-sector fixed asset shares:

$$\tilde{\omega}_{njt}^{K} = \frac{\text{Fassets}_{njt}}{\sum_{n' \in \mathcal{N}} \text{Fassets}_{n'jt}},$$

where Fassets_{njt} is sum of fixed assets of sector j establishments in region n. Then, I allocate region-sector real capital stock using these computed shares: $K_{njt} = \tilde{\omega}_{njt}^{K} \times K_{jt}$. For non-manufacturing sectors, I do not have information on region-sector level nominal fixed assets, so I use region-sector employment shares to allocate region-sector real capital stock.

Data used for constructing the regional exposure to balance sheet effect. KIS-VALUE is used for constructing industry-level exposure to balance sheet effects. It includes medium-sized firms that are not publicly traded. To compute the regional exposure in equation (B.2), I use five variables from KIS-VALUE: firm-level employment, foreign currency-denominated debt, foreign currency denominated assets, total assets, and total liabilities.

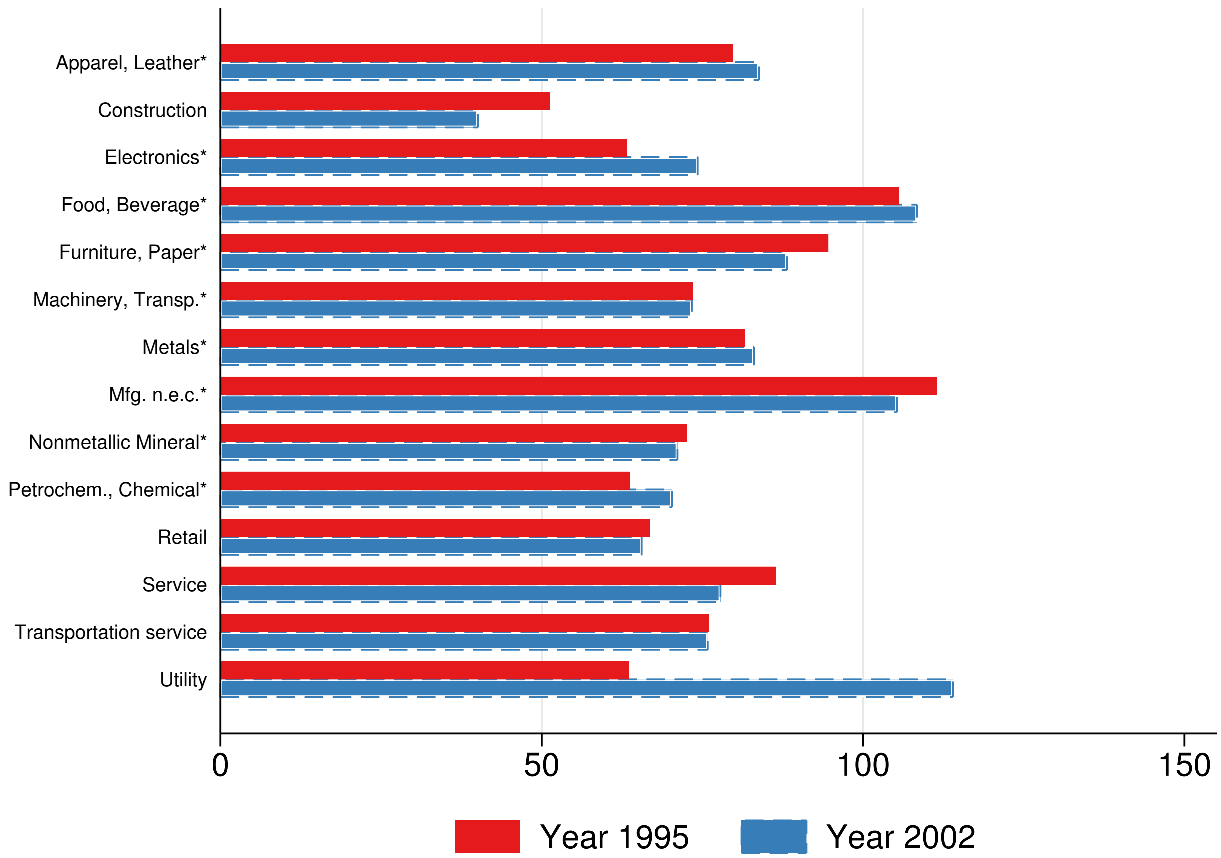
Data used for constructing the amenity index. Amenity index is computed using the Population Census, which is a 2% random sample of total population, Census of Establishment, and Mining and Manufacturing Survey. From these sources, I calculate the number of retail establishments, number of establishments in education service per capita, shares of workers using public transportation for commuting, number of factories per capita, and shares of white collar occupation workers, and number of business service establishments per capita.

Table A1: Sector Classification

Aggregated Industry	Industry
1. Commodity	Agriculture, hunting and forestry (A), Fishing (B) Mining and quarrying (C)
2. Food, Beverages, and Tobacco*	Food products and beverages (15), Tobacco products (16)
3. Textiles, Apparel, & Leather*	Textiles (17), Apparel (18) Leather, luggage, handbags, saddlery, harness, and footwear (19)
4. Wood, Paper & Printing*	Wood and of products, cork (20) Paper and paper products (21) Publishing and printing (22)
5. Chemicals, Petrochemicals, and Rubber and Plastic Products*	Coke, refined petroleum products and nuclear fuel (23) Chemicals and chemical products (24) Rubber and plastics products (25)
6. Non-Metallic Mineral Products*	Other non-metallic mineral products (26)
7. Basic and Fabricated Metals*	Basic metals (27), Fabricated metals (28)
8. Electrical Equipment*	Office, accounting and computing machinery (30) Electrical machinery and apparatus n.e.c. (31) Ratio, television and communication equipment and apparatus (32) Medical, precision, and optical instruments, watches and clocks (33)
9. Machinery and Transport Equipment*	Machinery and equipment n.e.c. (29) Motor vehicles, trailers, and semi trailers (34) Other transport equipment (35)
10. Manufacturing n.e.c.*	Manufacturing n.e.c. (36), Recycling (37)
11. Utilities	Electricity, gas and water supply (E)
12. Construction	Construction (F)
13. Whole and Retail	Wholesale and retail trade; repair of motor vehicles, motorcycles and personal and household goods (G)
14. Transport Service	Land transport; transport via pipelines (60) Water transport (61), Air transport (62) Supporting and auxiliary transport activities; activities of travel agencies (63)
15. Other Service	Hotels and restaurants (H) Post and telecommunications (64), Financial intermediation (J) Real estate, renting, and business activities (K) Public administration and defense (L); compulsory social security (L) Education (M), Health and social work (N) Other community, social and personal service activities (O) Activities of private households as employers and undifferentiated production activities of private households (P)

Note. The codes inside the parenthesis denote the ISIC rev 3.1. industry codes. Superscript * denotes for manufacturing sectors.

Figure A8: Coverage of the Employment Dataset (%)



Note. This figure depicts the fraction of total employment in each sector that is covered by establishments in the Census of Establishment. Total employment in each sector comes from the KLEMS database. Superscript * denotes for manufacturing sectors.

B. Empirics

B.1 Construction of Additional Controls

Regional exposure to balance sheet effects. To measure regional exposure to balance sheet effects, I first calculate sector-level exposure by averaging firm-level exposures within sectors, weighted by firm-level employment:

$$\text{BS}_{j,95} = \sum_{f \in \mathcal{F}_{j,95}} \frac{\text{Emp}_{fj,95}}{\sum_{f \in \mathcal{F}_{j,95}} \text{Emp}_{fj,95}} \times \frac{\text{Net foreign debt}_{fj,95}}{\text{Net worth}_{fj,95}}. \tag{B.1}$$

Net foreign debt ratio $\frac{\text{Net foreign debt}_{fj,95}}{\text{Net worth}_{fj,95}}$ represents the 1995 ratio of net foreign debt to net worth, indicating the financial burdens for firms with larger foreign debts (Kim et al., 2015). Net foreign debt is foreign currency-denominated debt minus foreign currency-denominated assets, and net worth is total assets minus total liabilities.

This ratio is computed using firm-level data from KIS-VALUE, the same dataset used by Kim et al. (2015). It covers firms with assets above 3 billion Korean Won (2.3 million USD in 2023). It is similar to US Compustat but it also includes medium-sized firms that are not publicly traded. We compute the ratio in 1995 because there are more observations in 1995 than 1994.

I take the employment-weighted average at the regional level:

$$\text{RegBS}_{n,95} = \sum_{j=1}^{J} \frac{\text{Emp}_{nj,94}}{\sum_{j=1}^{J} \text{Emp}_{nj,94}} \times \text{BS}_{j,95}. \tag{B.2}$$

Regions with higher employment in sectors with larger $\text{BS}_{j,95}$ are considered more exposed to balance sheet effects.

Proxies for migration frictions. To proxy migration frictions, I use the Mahalanobis distance:

$$\sqrt{(\boldsymbol{\lambda}_{n,94} - \boldsymbol{\lambda}_{m,94})' \boldsymbol{\Sigma}^{-1} (\boldsymbol{\lambda}_{n,94} - \boldsymbol{\lambda}_{m,94})},$$

where $\boldsymbol{\lambda}_{nt_0}$ is a $J \times 1$ vector representing region n's employment shares in 1994 or vote shares in 1995, and $\boldsymbol{\Sigma}^{-1}$ is a sample covariance matrix.

The index of dissimilarity in vote shares serves as a good proxy for regional conflicts in South Korea. Since the 1970s, the southwestern regions have faced cultural, economic, and political discrimination. The authoritarian government pursued an unequal development strategy by heavily investing in the manufacturing sectors of the southeastern regions (Choi and Levchenko, 2025). Additionally, in 1980, hundreds of people were massacred during an uprising in the southwestern regions against the authoritarian regime for democratic freedom. This unequal development strategy and the massacre intensified political regionalism. Since democratization in 1987, people in the southwestern regions have tended to vote for opposition party candidates against the authoritarian legacy, while those in the southeastern regions have generally supported the ruling party that continued the regime's policies.

Amenity index. Following Diamond (2016), I construct a regional amenity index using principal component analysis on several variables: log shares of white-collar occupation workers, log of the number of retail service establishments per capita, log of the number of education service establishments per capita, log shares of workers using public transportation for commuting, and log of the number of factories per capita. The overall amenity index is derived as the first principal component, with loadings of each variable reported in Table B2.

B.2 Additional Robustness Exercises

B.2.1 Sensitivity Checks to the Parallel Trend Assumption

To ensure robustness of the main findings against potential violations of the parallel trend assumption, I conduct sensitivity checks following the methodology proposed by Rambachan and Roth (2023). They recommend conducting event study analyses while imposing mild violations to the parallel trend assumptions, using estimated pre-trend information to gauge the magnitude of these violations.

I consider two classes of possible differences in trends: bounding relative magnitudes and smoothness restrictions. Bounding relative magnitudes is formalized as:

$$\Delta^{RM}(M) = \{\delta : \forall t \geq 0, |\delta_{t+1} - \delta_t| \leq M \times \max_{s \leq 0} |\delta_{s+1} - \delta_s|\}. \tag{B.3}$$

Here, $\Delta^{RM}(M)$ bounds the maximum post-treatment violation ($|\delta_{t+1} - \delta_t|$ for $t \geq 0$) between consecutive periods by M times the maximum pre-treatment violation ($\max_{s \leq 0} |\delta_{s+1} - \delta_s|$). The parameter M determines magnitude of the violation, with $M = 1$ being the natural benchmark, equating post-treatment violations to the maximum pre-treatment violations.

Smoothness restrictions are formalized as:

$$\Delta^{SD}(M) = \{\delta : |(\delta_{t+1} - \delta_t) - (\delta_t - \delta_{t-1})| \leq M, \forall t\}. \tag{B.4}$$

This assumes that differential trends evolve smoothly over time and limits how much their slope can change between consecutive periods. The parameter M controls magnitude of the slope changes. I set the maximum M to 50% of the standard errors of the corresponding estimates.

Overall, the event study results are robust to potential violations to the parallel trend assumption. Focusing on the estimates in 2000, which marks the end year of the long-difference specifications, Figure B9 reports the migration results. The inflow results are robust to violations up to 50% of the natural benchmark when bounding relative magnitudes (Panel A) and 25% of the standard error of the smoothness restrictions (Panel B). The outflow results show similar robustness (Panels C and D).

Figure B10 presents the employment results. Total employment, top 5 employment, and the non-top 5 employment results are robust up to 60%, 10%, and 50% of the natural benchmark, respectively (Panels A, B, and C). Regarding smoothness restrictions, total employment and non-top 5 employment are robust up to 50% of the standard errors, whereas top 5 employment up to 25% (Panels D, E, and

F).

B.2.2 Shift-Share Diagnostics

Consider the Bartik shock defined as $B_n = \sum_j Z_{nj} g_j$, where Z_{nj} represents region n's employment shares in sector j and g_j sector j's national gross output growth. $\mathbf{X}_n$ is a set of controls. Consider the following shift-share regression model:

$$y_n = \beta B_n + \mathbf{X}_n' \gamma + u_n.$$

Goldsmith-Pinkham et al. (2020) demonstrate that the estimate for β can be expressed as

$$\hat{\beta} = \sum_j \hat{\alpha}_j \hat{\beta}_j, \qquad \hat{\alpha}_j = \frac{g_j \mathbf{Z}_j' B^{\perp}}{\sum_k \mathbf{Z}_k' B^{\perp}}, \qquad \hat{\beta}_j = (Z_j' B^{\perp})^{-1} Z_j' Y,$$

where $\perp$ indicates that a variable is residualized by the the controls $\mathbf{X}$. The Bartik estimator can be decomposed into Rotemberg weights $\hat{\alpha}_k$ and just-identified IV estimators for each j $\hat{\beta}_j$.

Table B5 reports the Rotemberg weights and the just-identified IV estimators for the Bartik estimators in equations (3.1) and (3.4). Table B6 reports the summary of the Rotemberg weights. Because the regression models for the migration analysis are symmetric for inflows and outflows, I report results for outflows only, without loss of generality. Electrical equipment alone, one of the top 5 sectors, accounts for about 70% of the positive weights in the estimators.

In Table B7, I correlate employment shares of the top 5 or Electronic sector with other observables that could be related to unobservable confounding factors. I consider employment shares of the top 5 sectors most vulerable to balance sheet exposure based on $\text{BS}_{j,95}$ in equation (B.1) ($\text{Empsh}_{n,94}^{\text{top5, BS}}$), initial log unemployment rates in 1995, initial log housing prices in 1994, and initial amenity indices in 1995. Most correlations with these observables are statistically insignificant with low R-squared, except for the correlation between electrical equipment sector's employment shares and $\text{Empsh}_{n,94}^{\text{top5, BS}}$. The low R-squared and lack of statistical significance suggest that confounding factors predicting these observables are less concerning for violations of the identifying assumption.

B.3 Additional Tables and Figures

Table B2: Principal Component Analysis for Amenity Index

Variables	Loading
Log shares of white collar occupation workers	0.452
Log of the number of retail service establishment per capita	0.450
Log of the number of education service establishment per capita	0.426
Log shares of workers using public transportation for commuting	0.451
Log of the number of business service establishments per capita	0.450
Log of the number of factories per capita	−0.075

Note. This table reports loadings to create the overall amenity index.

Table B3: Robustness. No Commuting Effects

Dep.	Commuting				Migration (≥ 200km)			
	Inflows		Outflow		Inflow		Outflow	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\text{Bartik}_{n(m)t_0}$	−0.01	0.23	−0.03	0.02	0.09**	0.07*	−0.04**	−0.05***
	(0.27)	(0.24)	(0.06)	(0.08)	(0.03)	(0.04)	(0.02)	(0.02)
Origin (or Dest.) FE	✓	✓	✓	✓	✓	✓	✓	✓
Controls		✓		✓		✓		✓
Adj. R^2	0.29	0.51	0.55	0.67	0.29	0.33	0.48	0.52
# Cluster (Origin or Dest.)	53	53	53	53	54	54	54	54
N	466	466	466	466	1,852	1,852	1,852	1,852

Note. Standard errors are in parenthesis. *: $p < 0.1$; **: $p < 0.05$; ***: $p < 0.01$. Standard errors are clustered at the destination levels in columns 1-2 and 5-6, and the origin levels in columns 3-4 and 7-8. In columns 1-4, the dependent variables are changes in log commuting shares, defined as the number of commuters from origin m to destination n divided by origin m's lagged employment. 2,450 out of 2,916 pairs of commuting flows are dropped due to zero values. In columns 5-8, the dependent variables are changes in log migration shares excluding migration flows within 200km radius. $\text{Bartik}_{n(m)t_0}$ is the standardized Bartik shock (equation (3.2)). Columns 2, 4, 6, and 8 include the additional controls. Columns 1-2 and 5-6 (3-4 and 7-8) include origin (destination) fixed effects. All specifications are weighted by the initial population of origins.

Table B4: Robustness. Alternative Sample and Clustering, Spatial Correlations, and LASSO Control Selection. Migration Responses to the Crisis

Robustness	Excluding complexes	Two-way clustering	Spatial correlations							LASSO
			Spatial HAC			SCPC			Shift-share	
			50km	100km	150km	$\rho = 0.03$	$\rho = 0.05$	$\rho = 0.10$		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Panel A. Migration inflows									
Bartik_m	0.12^{***}	0.09^{***}	0.09^{***}	0.09^{***}	0.09^{***}	0.09^{***}	0.09^{***}	0.09^{***}	0.09^{***}	0.11^{***}
	(0.04)	(0.03)	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)
	[< 0.01]	[< 0.01]	[< 0.01]	[< 0.01]	[< 0.01]	[< 0.01]	[< 0.01]	[< 0.01]	[< 0.01]	[< 0.01]
	Panel B. Migration outflows									
Bartik_n	-0.06^{***}	-0.04^{***}	-0.04^{***}	-0.04^{***}	-0.04^{***}	-0.04^{***}	-0.04^{***}	-0.04^{***}	-0.04^{***}	-0.04^{***}
	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)
	[< 0.01]	[< 0.01]	[< 0.01]	[< 0.01]	[< 0.01]	[< 0.01]	[< 0.01]	[< 0.01]	[< 0.01]	[< 0.01]
Origin (or Dest.) FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Controls	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Controls (LASSO)										✓
N	2207	2,914	2,914	2,914	2,914	2,914	2,914	2,914	2,914	2,914

Note. Standard errors and p-values are reported in parenthesis and brackets, respectively. *: $p < 0.1$; **: $p < 0.05$; ***: $p < 0.01$. This table reports the OLS estimates of equation (3.1) for alternative forms of clustering, spatial correlations, and LASSO control section. In Panels A and B, the regression specifications are $\Delta \ln \mu_{nm} = \beta \text{Bartik}_m + \mathbf{X}_m' \boldsymbol{\gamma} + \delta_n + \varepsilon_{nm}$ and $\Delta \ln \mu_{nm} = \beta \text{Bartik}_n + \mathbf{X}_n' \boldsymbol{\gamma} + \delta_m + \varepsilon_{nm}$, respectively, where Bartik_n is the standardized Bartik shock (equation (3.2)). All specifications are weighted by the initial population of origins. Column 1 reports the estimates from the subsample excluding the capital city and regions with large complexes. Column 2 reports standard errors two-way clustered at both origin and destination levels. Columns 3-5 report the results with spatial HAC with different bandwidths (Conley, 1999; Colella et al., 2021). Columns 6-8 report standard errors based on spatial correlation principal components with different values of the maximal average pairwise correlation ρ (Müller and Watson, 2022). Column 9 reports standard errors adjusted for shift-shares (Adão et al., 2019). Column 10 reports the estimates, where controls among the additional controls and their polynomials and interaction terms up to the third order are selected based on the Belloni et al. (2014) post-double LASSO selection. Columns 1-9 include the additional controls. See Appendix B.1 for more details on the additional controls. All specifications include origin or destination fixed effects.

Table B5: Rotemberg Weights

Dep.	Outflows		Total emp		Top 5 emp		Non-top 5 emp	
	$\hat{\alpha}_j$	$\hat{\beta}_j$	$\hat{\alpha}_j$	$\hat{\beta}_j$	$\hat{\alpha}_j$	$\hat{\beta}_j$	$\hat{\alpha}_j$	$\hat{\beta}_j$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Food, Beverages, and Tobacco*	0.01	−2.93	0.00	−0.27	0.00	−0.47	0.00	−0.43
Non-Metallic Mineral Products*	0.01	−9.45	−0.02	0.23	−0.02	0.64	−0.01	0.14
Basic and Fabricated Metals*	−0.00	−1.77	−0.01	0.14	−0.00	0.51	−0.01	0.07
Manufacturing n.e.c.*	0.00	−3.35	0.00	0.16	0.00	0.36	0.00	0.14
Commodity	0.01	−4.00	0.01	0.04	0.01	0.26	0.01	−0.01
Chemicals*	0.05	−3.52	0.07	0.11	0.07	0.17	0.06	0.10
Utilities	−0.00	−4.41	0.00	0.37	0.00	0.37	0.00	0.20
Electrical Equipment*	0.72	−1.08	0.70	0.02	0.76	0.03	0.69	0.01
Construction	0.20	−2.52	0.23	0.09	0.16	0.17	0.25	0.08
Other Service	−0.00	−1.95	−0.00	0.07	−0.00	0.13	−0.00	0.06
Whole and Retail	0.00	−2.35	0.00	0.11	0.00	0.26	0.00	0.08
Textiles, Apparel, & Leather*	0.01	−1.00	0.01	0.08	0.02	0.10	0.01	0.09
Transport Service	0.00	−11.94	−0.01	0.31	−0.00	0.54	−0.00	0.25
Machinery and Transport Equipment*	−0.00	−3.85	−0.01	0.11	−0.00	0.14	−0.01	0.10
Wood, Paper & Printing*	0.00	1.02	0.00	−0.07	−0.00	0.35	0.00	0.01
Controls	✓	✓	✓	✓	✓	✓	✓	✓

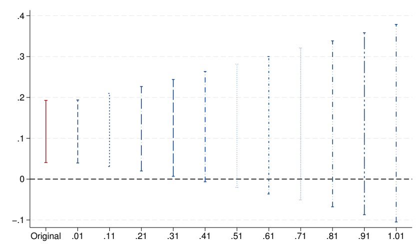
Note. This table reports the Rotemberg weights $\hat{\alpha}_j$ and just-identified IV estimators of equations (3.1) and (3.4) for each sector $\hat{\beta}_j$ (Goldsmith-Pinkham et al., 2020). All specifications include the additional controls. Superscript * denotes for manufacturing sectors.

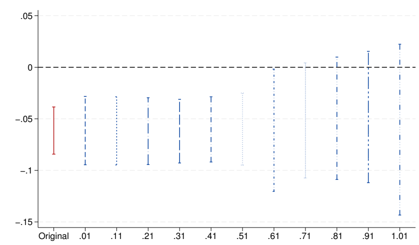
Table B6: Summary of Rotemberg Weights and Just-Identified IV Estimators

Dep.	Outflow	Total emp	Top 5 emp	Non-top 5 emp
	(1)	(2)	(3)	(4)
Panel A. Rotemberg weights $\hat{\alpha}_j$				
Share of $\hat{\alpha}_j > 0$	0.67	0.67	0.60	0.67
$\sum_{j\|\hat{\alpha}_j>0} \hat{\alpha}_j$	1.01	1.03	1.03	1.03
$\sum_{j\|\hat{\alpha}_j<0} \hat{\alpha}_j$	−0.01	−0.03	−0.03	−0.03
$\text{Mean}_{j\|\hat{\alpha}_j>0}\ \hat{\alpha}_j$	0.10	0.10	0.10	0.10
$\text{Mean}_{j\|\hat{\alpha}_j<0}\ \hat{\alpha}_j$	−0.00	−0.01	−0.01	−0.01
$\frac{\sum_{j\|\hat{\alpha}_j>0} \|\hat{\alpha}_j\|}{\sum_j \|\hat{\alpha}_j\|}$	0.97	0.97	0.97	0.97
Panel B. Just-identified IV estimators $\hat{\beta}_j$				
$\sum_{j\|\hat{\alpha}_j>0} \hat{\alpha}_j \hat{\beta}_j$	−1.66	0.05	0.07	0.04
$\sum_{j\|\hat{\alpha}_j<0} \hat{\alpha}_j \hat{\beta}_j$	0.05	−0.00	−0.01	−0.00

Note. This table reports the summary of the Rotemberg weights reported in Table B5.

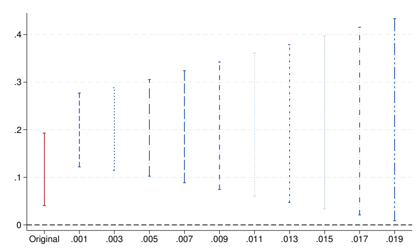
Figure B9: Robustness. Sensitivity Analysis for Potential Violations to the Parallel Trend Assumption. Event Study. Migration Responses to the Crisis

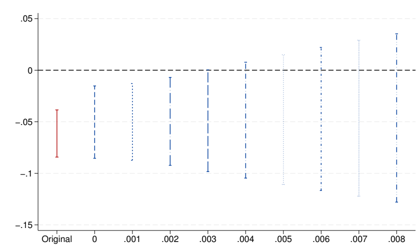




Bounding relative magnitudes

A. Inflow B. Outflow





Smoothness restrictions

C. Inflow D. Outflow

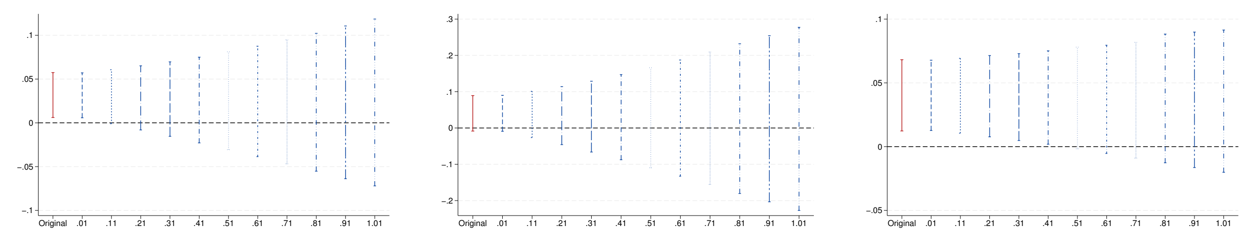
Note. This figure presents results of the sensitivity checks for potential violations of the parallel trend assumption based on the approach developed by Rambachan and Roth (2023). The figure reports the estimated 90% confidence intervals of the coefficient in 2000 for different levels of M in the axis. In Panels A and B, the restrictions on trends of the post-event periods are based on bounding relative magnitudes (equation (B.3)). In Panels C and D, the restrictions on trends of the post-event periods are based on smoothness restrictions, where the maximum values of M are set to 50% of the standard error of the corresponding estimates in 2000 (equation (B.4)). All specifications include the initial log employment, log unemployment rates, regional balance sheet exposure, log housing price, and amenity index of destinations or origins, all of which are interacted with the event-time dummies. All specifications include pair and year fixed effects. All specifications are weighted by the initial population of origins in 1994.

Table B7: Correlations between Initial Employment Shares and Observables

Dep.	Top 5 emp shares in 1994					Electrical equipment shares in 1994				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
$\text{Empsh}_{n,94}^{\text{top5,BS}}$	0.02				−0.03	−0.24*				−0.29*
	(0.12)				(0.13)	(0.14)				(0.15)
$\ln\left(\text{Unemp}_{n,95}\right)$		0.18			0.14		0.06			0.11
		(0.11)			(0.14)		(0.13)			(0.15)
$\ln\left(\text{Housing Price}_{n,94}\right)$			−3.66		−1.62			0.49		2.81
			(4.37)		(5.32)			(4.55)		(5.33)
$\text{Amenity}_{n,95}$				0.15	0.08				0.10	0.15
				(0.11)	(0.15)				(0.10)	(0.15)
Adj. R^2	−0.02	0.01	−0.00	0.00	−0.03	0.04	−0.01	−0.02	−0.01	0.02
N	54	54	54	54	54	54	54	54	54	54

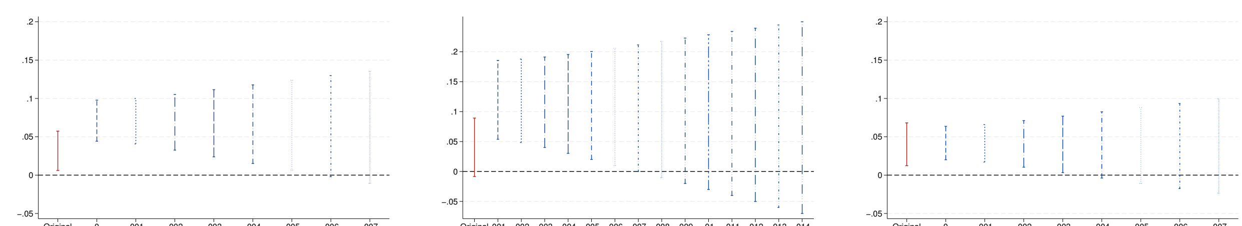
Note. Robust standard errors are reported in parenthesis. *: $p < 0.1$; **: $p < 0.05$; ***: $p < 0.01$. The dependent variables are employment shares of the top 5 sectors in columns 1-5 and the electrical equipment sector in columns 6-10. $\text{Empsh}_{n,94}^{\text{top5,BS}}$ is an employment share in the top 5 sectors that are most vulnerable to balance sheet effects, ranked based on $\text{BS}_{j,95}$ (equation (B.1)). $\ln \text{Unemp}_{n,95}$ are log unemployment rates in 1995. $\ln\left(\text{Housing Price}_{n,94}\right)$ are log housing prices in 1994. $\text{Amenity}_{n,95}$ are the amenity indices in 1995. See Section B.1 for more details on these variables. All variables are standardized.

Figure B10: Robustness. Sensitivity Analysis for Potential Violations to the Parallel Trend Assumption. Event Study. Employment Responses to the Crisis



Bounding relative magnitudes

A. Total emp B. Top 5 emp C. Non-top 5 emp



Smoothness restrictions

D. Total emp E. Top 5 emp F. Non-top 5 emp

Note. This figure presents results of the sensitivity checks for potential violations of the parallel trend assumption based on the approach developed by Rambachan and Roth (2023). The figure reports the estimated 90% confidence intervals of the coefficient in 2000 of equation (3.6) for different levels of M in the axis. In Panels A, B, and C, the restrictions on trends of the post-event periods are based on bounding relative magnitudes (equation (B.3)). In Panels D, E, and F, the restrictions on trends of the post-event periods are based on smoothness restrictions, where the maximum values of M are set to 50% of the standard error of the corresponding estimates in 2000 (equation (B.4)). All specifications include the initial log employment, initial regional balance sheet exposure, log unemployment rates, log housing price, and amenity index, all of which are interacted with the event-time dummies. All specifications include region and year fixed effects. See Appendix B.1 for more details on the additional controls. All specifications are weighted by the initial employment in 1994.

Table B8: Robustness. Alternative Sample and Clustering, Spatial Correlations, and LASSO Control Selection. Employment Responses to the Crisis

Robustness	Excluding complexes	Spatial correlations							LASSO
		Spatial HAC			SCPC			Shift-share	
		50km	100km	150km	$\rho = 0.03$	$\rho = 0.05$	$\rho = 0.10$		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Panel A. Total employment								
Bartik_n	0.05*	0.03**	0.03**	0.03**	0.03***	0.03***	0.03***	0.03**	0.03***
	(0.02)	(0.01)	(0.01)	(0.02)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)
	[0.06]	[0.01]	[0.01]	[0.03]	[< 0.01]	[< 0.01]	[< 0.01]	[< 0.01]	[< 0.01]
	Panel B. Top 5 employment								
Bartik_n	0.07	0.06**	0.06**	0.06**	0.06***	0.06***	0.06***	0.06*	0.06**
	(0.04)	(0.03)	(0.03)	0.03)	(0.00)	(0.00)	(0.00)	(0.03)	(0.02)
	[0.13]	[0.03]	[0.03]	[0.04]	[< 0.01]	[< 0.01]	[< 0.01]	[0.05]	[0.01]
	Panel B. Non-top 5 employment								
Bartik_n	0.03	0.03***	0.03***	0.03***	0.03***	0.03***	0.03***	0.03**	0.04***
	(0.02)	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)
	[0.14]	[< 0.01]	[< 0.01]	[< 0.01]	[< 0.01]	[< 0.01]	[< 0.01]	[0.03]	[< 0.01]
Controls	✓	✓	✓	✓	✓	✓	✓	✓	
Controls (LASSO)									✓
N	47	54	54	54	54	54	54	54	54

Note. Standard errors and p-values are reported in parenthesis and brackets, respectively. *: $p < 0.1$; ** : $p < 0.05$; ***: $p < 0.01$. This table reports the OLS estimates of equation (3.4) for alternative forms of clustering, spatial correlations, and LASSO control section. In Panels A, B, and C, the dependent variables are the changes in the log total employment, top 5 employment, and non-top 5 employment between 1997-2000, respectively. Column 1 reports the estimates from the subsample excluding the capital city and regions with large complexes. Columns 2-4 report the results with spatial HAC with different bandwidths (Conley, 1999; Colella et al., 2021). Columns 5-7 report standard errors based on spatial correlation principal components different values of the maximal average pairwise correlation ρ (Müller and Watson, 2022). Column 8 reports standard errors adjusted for shift-shares (Adão et al., 2019). Column 9 reports the estimates, where controls among the additional controls and their polynomials and interaction terms up to the third order, using the Belloni et al. (2014) post-double LASSO selection. Columns 1-8 include the additional controls. All specifications are weighted by the initial employment in 1994.

C. Quantitative Framework

C.1 Real GDP

In this subsection, I describe the aggregation of real GDP at the aggregate and regional levels. I first define sectoral PPIs using each region's gross output shares within sectors as a Tornqvist index:

$$\widehat{\mathrm{PPI}}_{jt} = \sum_{n=1}^{N} \omega_{njt}^{\mathrm{PPI}} \hat{P}_{njt}, \qquad \omega_{njt}^{\mathrm{PPI}} = \frac{1}{2}\left(\frac{\mathrm{GO}_{nj,t-1}}{\sum_{n=1}^{N} \mathrm{GO}_{nj,t-1}} + \frac{\mathrm{GO}_{njt}}{\sum_{n=1}^{N} \mathrm{GO}_{njt}}\right). \tag{C.1}$$

The hat denotes time differences for any variable x: $\hat{x}_{t+1} = x_{t+1}/x_t$. $\tilde{\omega}_{njt}^{\mathrm{PPI}}$ is the average of region n's shares of sector j gross output in periods $t-1$ and t.

Using these sectoral PPIs, I define aggregate real GDP:

$$\hat{Y}_t^r = \sum_{n=1}^{N} \sum_{=1}^{J} \omega_{njt}^{\mathrm{agg},r} \widehat{\mathrm{VA}}_{njt}^r, \quad \widehat{\mathrm{VA}}_{njt}^r = \frac{\widehat{\mathrm{VA}}_{njt}}{\widehat{\mathrm{PPI}}_{jt}},$$
$$\omega_{njt}^{\mathrm{agg},r} = \frac{1}{2}\left(\frac{\mathrm{VA}_{nj,t-1}}{\sum_{n=1,j=1}^{N,J} \mathrm{VA}_{nj,t-1}} + \frac{\mathrm{VA}_{njt}}{\sum_{n=1,j=1}^{N,J} \mathrm{VA}_{njt}}\right). \tag{C.2}$$

VA_{njt} is region-sector nj's nominal value-added: $\mathrm{VA}_{njt} = \gamma_j^H \mathrm{GO}_{njt}$. $\widehat{\mathrm{VA}}_{njt}^r$ is region-sector nj's real value-added growth deflated by sectoral PPIs. Given that real GDP is a measure for real value-added, I use the value-added shares for aggregation. Similarly, I define regional real GDP using the regional weights:

$$Y_{nt}^r = \sum_{j=1}^{J} \omega_{njt}^{reg,r} \widehat{\mathrm{VA}}_{njt}^r, \qquad \omega_{njt}^{\mathrm{reg},r} = \frac{1}{2}\left(\frac{\mathrm{VA}_{nj,t-1}}{\sum_{j=1}^{J} \mathrm{VA}_{nj,t-1}} + \frac{\mathrm{VA}_{njt}}{\sum_{j=1}^{J} \mathrm{VA}_{njt}}\right). \tag{C.3}$$

C.2 Microfoundation for Shocks

C.2.1 Balance Sheet Effects

In this section, I develop a one-period model of firms operating under credit constraints to illustrate that productivity shocks A_{njt} can capture balance sheet effects. The model is based on Kim et al. (2015) and I will follow their notations.

The setup is the same with the baseline model, except for credit constraints. One feature of the crisis is a large depreciation in the Korean won, and the percentage increase in the exchange rate is denoted as $\Delta e_{won/\$}$. Before the crisis occurs, each perfectly competitive firm in region-sector nj has an initial net worth of N_{njt_0} and a net foreign debt d_{njt_0}. The net worth after the crisis is $n_{njt_1} = n_{njt_0} - d_{njt_0} \Delta e_{won/\$}$.

Firms are subject to working capital constraints. The working capital needed to finance firms' input costs can be covered by either their net worth or bank loan b_{njt_1}:

$$W_{njt_1}H_{njt_1} + \sum_{k=1}^{J} P_{nkt_1}M_{nkt_1} = n_{njt_1} + b_{njt_1}.$$

Firms may borrow from banks at the rate $r_{t_1}(n_{njt_1}, A_{njt_1}) = r^f_{t_1}(1+\eta(n_{njt_1}, A_{njt_1}))$. Here, $r^f_{t_1}$ is the world risk free rate and $\eta(n_{njt_1}, A_{njt_1})$ is the financing premium that decreases with productivity and net worth n_{njt_1}.

Solving the cost minimization problem yields:

$$c_{njt_1} = \frac{n_{njt_1} + b_{njt_1} r_{t_1}(n_{njt_1}, A_{njt_1})}{n_{njt_1} + b_{njt_1}} \frac{W_{njt_1}^{\gamma_j^H} \prod_k P_{nkt_1}^{\gamma_j^k}}{A_{njt_1}}.$$

The first-term captures balance sheet effects. After the crisis, because firms' net worth decreases ($n_{njt_0} > n_{njt_1}$), larger shares of input expenditures are subject to working capital constraints. Additionally, the interest rate becomes higher due to the lower net worth. Because $\frac{n_{njt_1}+b_{njt_1}r_{t_1}(n_{njt_1},A_{njt_1})}{n_{njt_1}+b_{njt_1}}$ and A_{njt} enter the unit cost isomorphically, they cannot be separately identified without additional data moments.

C.2.2 Downward Nominal Rigidity and Unemployment

In this section, I show that unemployment due to region-sector specific downward nominal rigidity can be related to E_{njt} by showing that employment rates show up in the position of E_{njt} in equations (4.8) and (4.9). For simplicity, I assume that $\psi = 0$ so that working hours do not vary with regional wage indices.

Following Rodriguez-Clare et al. (2022), I introduce downward nominal rigidity (DWNR) at the region-sector level:

$$W_{njt} \geq \delta_{njt} W_{nj,t-1}, \qquad \delta_{njt} \geq 0.$$

δ_{njt} is a region-sector specific time-varying parameter, with a higher value corresponding to tighter degree of the rigidity. $\delta_{njt} = 0$ implies no DWNR in region-sector nj in period t. The DWNR leads to unemployment, an employment level below labor supply in efficiency units:

$$H_{njt} \leq \tilde{H}_{njt}, \tag{C.4}$$

where H_{njt} is an amount of employed effective labor and $\tilde{H}_{njt}$ is total effective labor supply. $e_{njt} = H_{njt}/\tilde{H}_{njt}$ is employment rate of effective labor. When households allocate their workers in sector j, they consider both wages W_{njt} and employment rates e_{njt}.

Households in region n allocate their worker ω to sector j only if sector j generates the highest labor income adjusted for unemployment rates, over other sectors: $\varepsilon^{\omega}_{njt} \in \Omega_{njt}$, where $\Omega_{njt} = \{\varepsilon_t | W_{njt}e_{njt}\varepsilon^{\omega}_{njt} \geq W_{nkt}e_{nkt}\varepsilon^{\omega}_{nkt}, \forall k \in \mathcal{J}\}$. $\varepsilon^{\omega}_{njt}$ is independently and identically distributed from a multivariate Fréchet distribution across regions and periods: $F_{nt}(\varepsilon_t) = \exp(-\sum_{j=1}^{J} \varepsilon_{njt}^{-\theta})$ with the shape parameter $\theta > 1$. To simplify the analysis, I assume that sum of wages generated in region-sector nj is equally distributed to all workers in nj. Shares of workers allocated to sector j in region n are

$$\lambda_{njt} = \frac{(e_{njt}W_{njt})^{\theta}}{\sum_k (e_{nkt}W_{nkt})^{\theta}}. \tag{C.5}$$

Total labor income of region n's household is

$$W_{nt} = \Big[\sum_{j=1}^{J}(W_{njt}e_{njt})^{\theta}\Big]^{\frac{1}{\theta}}.$$

Total labor supply is

$$\tilde{H}_{njt} = \lambda_{njt}^{\frac{\theta-1}{\theta}} h_{nt} L_{nt}.$$

I introduce a nominal anchor that prevents nominal wages from rising so much, making the DWNR constraints binding every period. Following Rodriguez-Clare et al. (2022), I assume that the nominal GDP of South Korea grows at a constant rate of φ:

$$\sum_{n=1}^{N}\sum_{j=1}^{J} W_{njt}H_{njt} = \varphi \sum_{n=1}^{N}\sum_{j=1}^{J} W_{nj,t-1}H_{nj,t-1}. \tag{C.6}$$

Labor market clearing conditions satisfy

$$W_{njt}H_{njt} = \gamma_j^H \mathrm{GO}_{njt}$$

and complementary slackness that combines equations (C.2.2) and (C.4)

$$(\tilde{H}_{njt} - H_{njt})(W_{njt} - \delta_{nj}W_{nj,t-1}) = 0.$$

Other equilibrium conditions and variables are expressed in the same to those of the baseline model in the main text.

Employment rates e_{njt}^{θ} in equation (C.5) can be mapped to labor supply shocks in E_{njt} in equation (4.8). From information on employment shares, e_{njt} can be identified conditional on wages. From e_{njt}, values of δ_{njt} can be indirectly inferred. However, market clearing conditions of the model with DWNR differ from those of the baseline, and therefore, it will have different welfare and general equilibrium implications.

C.3 Regression Model of Migration Elasticity

In this section, I describe the derivation and estimation procedure of equation (4.16).

Derivation of equation (4.16). From equations (4.11) and (4.12), I can derive the following equation:

$$V_{nt} = \ln U_{nt} - \nu \ln \mu_{nmt} + \beta V_{m,t+1} + B_{mt} - \tau_{nmt}, \quad \forall n, m.$$

Using the above equation for pairs nn and nm and subtracting one from the other,

$$\ln \frac{\mu_{nmt}}{\mu_{nnt}} = \frac{\beta}{\nu}(V_{m,t+1} - V_{n,t+1}) + \frac{1}{\nu}(B_{mt} - B_{nt}) - \frac{1}{\nu}\tau_{nmt}$$

Using equation (4.11), the above expression can be re-written as

$$\ln \frac{\mu_{nmt}}{\mu_{nnt}} = \frac{\beta}{\nu} \ln \frac{U_{m,t+1}}{U_{n,t+1}} + \frac{\beta}{\nu}\Bigg(\nu \ln \sum_{n'} \exp(\beta V_{n',t+2} - \tau_{mn',t+1}) \\ - \nu \ln \sum_{n'} \exp(\beta V_{n',t+2} - \tau_{nn',t+1})\Bigg) + \frac{1}{\nu}(B_{m,t} - B_{nt}) - \frac{1}{\nu}\tau_{nmt}.$$

Using equation (4.12) and subtracting and adding $\beta V_{m,t+2} + B_{m,t+1} - \tau_{mn,t+1}$ on the right-hand side of the above equation, I obtain that

$$\ln \frac{\mu_{nmt}}{\mu_{nnt}} = \frac{\beta(1+\psi)}{\nu} \ln \frac{W_{m,t+1}/P_{m,t+1}}{W_{n,t+1}/P_{n,t+1}} + \beta \ln \frac{\mu_{mn,t+1}}{\mu_{mm,t+1}} \\ + \frac{1}{\nu}\Big((B_{mt} - B_{nt}) - \beta(B_{m,t+1} - B_{n,t+1})\Big) + \frac{1}{\nu}(\beta\tau_{mn,t+1} - \tau_{nm,t}).$$

Note that $1 + \iota_t$ common across regions are canceled out in the numerator and denominator of $U_{m,t+1}/U_{n,t+1}$.

Migration frictions and amenities can be decomposed into time-invariant and time-varying components: $\tau_{nmt} = \tilde{\tau}_{nm} + \tilde{\tau}_{nmt}$ and $B_{nt} = \tilde{B}_m + \tilde{B}_{mt}$. This gives me the following estimable regression model:

$$\ln \frac{\mu_{nmt}}{\mu_{nnt}} = \frac{\beta(1+\psi)}{\nu} \ln \frac{W_{m,t+1}/P_{m,t+1}}{W_{n,t+1}/P_{n,t+1}} + \beta \ln \frac{\mu_{mn,t+1}}{\mu_{mm,t+1}} + \delta_{nm} + \varepsilon_{nmt}. \tag{C.7}$$

The pair time-invariant fixed effects δ_{nm} absorb time invariant migration frictions and amenities: $\frac{\beta-1}{\nu}\tilde{\tau}_{nm}$ and $\frac{1-\beta}{\nu}(\tilde{B}_m - \tilde{B}_n)$. $\tilde{\varepsilon}_{nmt}$ is the structural error term that is a function of time-varying migration frictions and amenities:

$$\tilde{\varepsilon}_{nmt} = \frac{1}{\nu}\Big((\beta\tilde{\tau}_{mn,t+1} - \tilde{\tau}_{nmt}) + (\tilde{B}_{mt} - \tilde{B}_{nt}) - \beta(\tilde{B}_{m,t+1} - \tilde{B}_{n,t+1})\Big).$$

Differencing equation (C.7) and adding controls give equation (4.16).

Imputation of CPI. Estimating equation (4.16) requires information on regional price levels. I construct regional price levels using data on regional CPI and housing prices, obtained from the Statistics Korea. Regional CPI information is only available for a few regions, whereas information of regional housing prices is available for all regions. Therefore, following Moretti (2017), I impute CPI for regions with missing CPI. For a subset of regions with non-missing CPI, I run the following regression:

$$gCPI_{n,t+1} = \pi \times gHP_{n,t+1} + \delta_t + \varepsilon_{nt},$$

where $gCPI_{n,t+1}$ and $gHP_{n,t+1}$ are growth of CPI and housing prices in region n between t and $t+1$. Using the estimated coefficients $\hat{\pi}$ and $\hat{\delta}_t$, and housing prices, I impute growth of CPI for missing regions and compute CPI after normalizing the 1992 level to one.

C.4 Shock Formulation of the Model

Following Caliendo et al. (2019), I break down the equilibrium into two parts: a static equilibrium in which goods and factor market clearing conditions hold, taking populations as given, and a dynamic equilibrium that solves forward-looking migration decisions of households.

Static equilibrium. Unit costs are expressed as:

$$\hat{c}_{nj,t+1} = \frac{1}{\hat{A}_{nj,t+1}} (\hat{W}_{nj,t+1})^{\gamma_j^H} \prod_{k=1}^{J} (\hat{P}_{nj,t+1})^{\gamma_j^k}.$$

Price indices are expressed as:

$$(\hat{P}_{nj,t+1})^{1-\sigma} \sum_{m \in \mathcal{N}} \pi_{mnt}^j (\hat{c}_{nj,t+1})^{1-\sigma} + \pi_{Fnt}^j (\hat{P}_{j,t+1}^F)^{1-\sigma}.$$

Domestic and import trade shares are

$$\hat{\pi}_{mn,t+1}^j = \left(\frac{\hat{c}_{mj,t+1}}{\hat{P}_{nj,t+1}} \right)^{1-\sigma} \quad \text{and} \quad \hat{\pi}_{Fn,t+1}^j = \left(\frac{\hat{P}_{j,t+1}^F}{\hat{P}_{nj,t+1}} \right)^{1-\sigma}.$$

Exports are

$$\mathrm{EX}_{nj,t+1} = \mathrm{EX}_{njt} (\hat{c}_{nj,t+1})^{1-\sigma} \hat{D}_{j,t+1}^F.$$

Regional wage indices are

$$\hat{W}_{n,t+1} = \left(\sum_{j \in \mathcal{J}} \lambda_{njt} \hat{E}_{nj,t+1} \hat{W}_{nj,t+1}^{\theta} \right)^{\frac{1}{\theta}}.$$

Regional employment shares are

$$\hat{\lambda}_{nj,t+1} = \frac{\hat{E}_{nj,t+1} \hat{W}_{nj,t+1}^{\theta}}{\hat{W}_{n,t+1}^{\theta}}.$$

Working hours are

$$\hat{h}_{nt} = \left(\frac{\widehat{(1+\iota_t)} \hat{W}_{nt}}{\hat{P}_{nt}} \right)^{\psi}.$$

Indirect utility is

$$\hat{U}_{n,t+1} = \left(\frac{\widehat{(1+\iota_t)} \hat{W}_{n,t+1}}{\hat{P}_{n,t+1}} \right)^{1+\psi}.$$

Total sectoral labor supply is

$$\hat{H}_{nj,t+1} = \hat{E}_{njt}\left(\frac{\hat{W}_{njt}}{\hat{W}_{nt}}\right)^{\theta-1}\hat{h}_{n,t+1}\hat{L}_{n,t+1}.$$

Goods market clearing is

$$\text{GO}_{nj,t+1} = \sum_{m=1}^{N}\pi^{j}_{mn,t+1}\Bigg[\sum_{k\in\mathcal{J}}\gamma^{j}_{k}\text{GO}_{mk,t+1} + \alpha_j\Big((1+\iota_{t+1})\hat{W}_{n,t+1}\hat{h}_{n,t+1}\hat{L}_{n,t+1}W_{nt}h_{nt}L_{nt}\Big)\Bigg] + \text{EX}_{nj,t+1}.$$

Labor market clearing is

$$W_{nj,t+1}H_{nj,t+1} = \gamma^{H}_{j}\text{GO}_{nj,t+1}.$$

Dynamic equilibrium. Define $u_{nt} = \exp(V_{nt})$, $m_{nmt} = \exp(\tau_{nmt})$, and $b_{nt} = \exp(B_{nt})$. Then, $\hat{u}_{n,t+1} = \exp(V_{n,t+1} - V_{nt})$, $\hat{m}_{nm,t+1} = \exp(\tau_{nm,t+1} - \tau_{nmt})$, and $\hat{b}_{nt} = \exp(B_{nt} - B_{n,t-1})$. Given initial allocation and anticipated sequences of shocks in changes, the following system of nonlinear equations is satisfied.

Migration shares are expressed as

$$\mu_{nm,t+1} = \frac{\mu_{nmt}(\hat{u}_{m,t+2})^{\frac{\beta}{\nu}}(\hat{b}_{m,t+1})^{\frac{1}{\nu}}(\hat{m}_{nm,t+1})^{-\frac{1}{\nu}}}{\sum_{m'=1}^{N}\mu_{nm't}(\hat{u}_{m',t+2})^{\frac{\beta}{\nu}}(\hat{b}_{m',t+1})^{\frac{1}{\nu}}(\hat{m}_{nm',t+1})^{-\frac{1}{\nu}}}. \tag{C.8}$$

Population evolves according to

$$L_{n,t+1} = \sum_{m=1}^{N}\mu_{mnt}L_{mt}. \tag{C.9}$$

Value functions are

$$\hat{u}_{n,t+1} = \hat{U}_{n,t+1}\left(\sum_{m'=1}^{N}\mu_{nm't}(\hat{u}_{m',t+2})^{\frac{\beta}{\nu}}(\hat{b}_{m',t+1})^{\frac{1}{\nu}}(\hat{m}_{nm',t+1})^{-\frac{1}{\nu}}\right)^{\nu}. \tag{C.10}$$

Derivation of equation (C.8). Migration shares can be expressed as

$$\begin{aligned}\mu_{nm,t+1} &= \frac{\exp\big(\beta V_{m,t+2} + B_{m,t+1} - \tau_{nm,t+1}\big)^{\frac{1}{\nu}}}{\sum_{m'=1}^{N}\exp\big(\beta V_{m',t+2} + B_{m',t+1} - \tau_{nm',t+1}\big)^{\frac{1}{\nu}}}\\ &= \frac{(\hat{u}_{m,t+2})^{\frac{\beta}{\nu}}(\hat{b}_{m,t+1})^{\frac{1}{\nu}}(\hat{m}_{nm,t+1})^{-\frac{1}{\nu}}\exp\big(\beta V_{m,t+1} + B_{mt} - \tau_{nmt}\big)^{\frac{1}{\nu}}}{\sum_{m'=1}^{N}(\hat{u}_{m',t+2})^{\frac{\beta}{\nu}}(\hat{b}_{m',t+1})^{\frac{1}{\nu}}(\hat{m}_{nm',t+1})^{-\frac{1}{\nu}}\exp\big(\beta V_{m',t+1} + B_{m't} - \tau_{nm't}\big)^{\frac{1}{\nu}}}.\end{aligned}$$

After dividing both the denominator and numerator of the above equation by $\sum_{m'=1}^{N}\exp(\beta V_{m',t+1} + B_{m't} - \tau_{nm't})^{\frac{1}{\nu}}$, I can obtain the expression in equation (C.8).

Derivation of equation (C.10). After time-differencing equation (4.11),

$$V_{n,t+1} - V_{n,t} = \ln U_{n,t+1} - \ln U_{nt} + \nu \ln \frac{\sum_{m=1}^{N} \exp(\beta V_{m,t+2} + B_{m,t+1} - \tau_{nm,t+1})^{\frac{1}{\nu}}}{\sum_{m=1}^{N} \exp(\beta V_{m,t+1} + B_{mt} - \tau_{nmt})^{\frac{1}{\nu}}}.$$

Taking exponential from both sides and using the expressions of $\hat{u}_{n,t+1}$ and $\mu_{nm,t+1}$, I can obtain the expression in equation (C.10).

C.5 Algorithm

I describe the solution algorithm used to solve the model.

Data input.

- Region-sector gross output $\{\mathrm{GO}_{njt_0}\}_{n=1,j=1}^{N,J}$
- Region-sector export $\{\mathrm{EX}_{njt_0}\}_{n=1,j=1}^{N,J}$
- Region-sector employment shares $\{\lambda_{njt_0}\}_{n=1,j=1}^{N,J}$
- Regional population $\{L_{nt_0}\}_{n=1}^{N}$
- Domestic region-to-region sectoral trade shares $\{\pi_{nmt_0}^{j}\}_{n=1,m=1,j=1}^{N,N,J}$
- Region-sector import shares $\{\pi_{Fnt}^{j}\}_{n=1,j=1}^{N,J}$
- Region-to-region migration flows $\{\mu_{nm,t_0-1}\}_{n=1,m=1}^{N,N}$

Structural parameters.

- Migration elasticity $1/\nu$
- Sectoral labor supply elasticity θ
- Frisch labor elasticity ψ
- Elasticity of substitution σ
- Cobb-Douglas preference expenditure shares $\{\alpha_j\}_{j=1}^{J}$
- Cobb-Douglas production fu nction shares $\{\gamma_j^H, \gamma_j^k\}_{j=1,k=1}^{J,J}$

Algorithm.

- Step 1. Given the path of the shocks $\{\hat{\boldsymbol{\Psi}}_t\}_{t=98}^{T}$ and $\{\hat{m}_{nmt}\}_{n,m=1,t=97}^{N,T}$, guess the path of $\{\hat{u}_{nt}^{(0)}\}_{n=1,t=98}^{N,T+1}$. The path converges at $T+1$, so set $\hat{u}_{n,T+1}^{(0)} = 1$, $\forall n \in \mathcal{N}$.
- Step 2. Given the initial allocation of migration shares $\{\mu_{nmt_0}\}_{n,m=1}^{N}$, using the guessed $\{\hat{u}_{nt}^{(0)}\}_{n=1,t=t_0+1}^{N,T+1}$, compute path of migration shares $\{\mu_{nmt}\}_{n,m=1,t=t_0+1}^{N,T+1}$ using equation (C.8). Using the computed migration shares $\{\mu_{nmt}\}_{n,m=1,t=1}^{N,T+1}$, compute population for periods $t \geq t_0+1$ using equation (C.9) and then, compute $\{\hat{L}_{nt}\}_{n=1,t=t_0}^{N,T}$.
- Step 3. For $t > t_0$, Using calculated $\{\hat{L}_{n,t+1}\}_{n=1}^{N}$, solve for $\{\hat{W}_{nj,t+1}\}_{n=1,j=1}^{N,J}$ that satisfy the system of equations of the static equilibrium in Section C.4 for each t.
  (a) Guess $\{\hat{W}_{nj,t+1}^{(0)}\}_{n=1,j=1}^{N,J}$ and $\{\hat{P}_{nj,t+1}^{(0)}\}_{n=1,j=1}^{N,J}$
  (b) Based on $\{\hat{W}_{nj,t+1}^{(0)}\}_{n=1,j=1}^{N,J}$, calculate the regional wage indices $\{\hat{W}_{n,t+1}\}_{n=1}^{N}$ and regional employment shares $\{\hat{\lambda}_{nj,t+1}\}_{n=1,j=1}^{N,J}$. Then, iterate $\{\hat{P}_{nj,t+1}^{(0)}\}_{n=1,j=1}^{N,J}$ until convergence using the formulas for unit costs and price indices in Section C.4.

(c) Calculate $\{\hat{W}^{(1)}_{nj,t+1}\}^{N,J}_{n=1,j=1}$ that satisfy the labor market clearing condition and check whether $|\hat{W}^{(1)}_{nj,t+1} - \hat{W}^{(0)}_{nj,t+1}| < \varepsilon$ for some tolerance level ε. If not, use $\{\hat{W}^{(1)}_{nj,t+1}\}^{N,J}_{n=1,j=1}$ as the new guess and go back to step (a).

- Step 4. For each t, solve backward for $\{\hat{u}^{(1)}_{nt}\}^{N,T+1}_{n=1,t=t_0+1}$:

$$\hat{u}^{(1)}_{n,t+1} = \hat{U}_{n,t+1}\left(\sum_{m=1}^{N}\mu_{nmt}(\hat{u}^{(0)}_{m,t+2})^{\frac{\beta}{\nu}}(\hat{b}_{m,t+1})^{\frac{1}{\nu}}(\hat{m}_{nm,t+1})^{-\frac{1}{\nu}}\right)^{\nu}.$$

- Step 5. Take $\{(1-\omega)\hat{u}^{(0)}_{nt} + \omega\hat{u}^{(1)}_{nt}\}^{N,T+1}_{n=1,t=t_0+1}$ for some weights $\omega \in (0,1]$, and return to Step 2. Continue until both $\{\hat{u}^{(1)}_{nt}\}^{N,T+1}_{n=1,t=t_0+1}$ converge.

C.6 Calibration of Regional Trade Shares and Shocks

C.6.1 Calibration of Regional Trade Shares

I begin by explaining the calibration procedure of region-sector exports, region-sector import shares, and domestic region-to-region sectoral trade shares. The output of the procedure is used as inputs for recovering exogenous shocks.

Data input.

- Region-sector gross output $\{\text{GO}_{njt}\}^{N,J,02}_{n=1,j=1,t=97}$
- Sectoral exports $\{\text{EX}_{jt}\}^{J,02}_{j=1,t=97}$
- Sectoral imports $\{\text{IM}_{jt}\}^{J,02}_{j=1,t=97}$
- Parametrized trade costs $\{d^j_{mn}, d^j_{Fn}\}^{N,N,J}_{m=1,n=1,j=1}$

Algorithm.

- Step 1. Let $\tilde{c}_{njt}$ denote for the unit cost of sector j in region n: $\tilde{c}_{njt} = c_{njt}/A_{njt}$. The static trade equilibrium of each period can be expressed as follows:

$$\begin{aligned}
\text{GO}_{njt} &= (d^j_{nF}\tilde{c}_{njt})^{1-\sigma}D^F_{jt} + \sum_{m=1}^{N}\pi^j_{nmt}\left[\sum_{k=1}^{J}\gamma^j_k\text{GO}_{mkt} + \alpha_j\left(\sum_{k'=1}^{J}(1+\iota_t)\gamma^H_{k'}\text{GO}_{mk't}\right)\right],\\
\text{IM}_{jt} &= \sum_{n=1}^{N}\left[\pi^j_{Fnt}\left[\sum_{k=1}^{J}\gamma^j_k\text{GO}_{mkt} + \alpha_j\left(\sum_{k'=1}^{J}(1+\iota_t)\gamma^H_{k'}\text{GO}_{mk't}\right)\right]\right],\\
\text{EX}_{jt} &= \sum_{n=1}^{N}\text{EX}_{njt},
\end{aligned}$$

$$\pi^j_{mnt} = \frac{(d^j_{mn}\tilde{c}_{mjt})^{1-\sigma}}{\sum_{m'=1}^{N}(d^j_{m'n}\tilde{c}_{m'jt})^{1-\sigma} + (d^j_{nF}P^F_{jt})^{1-\sigma}}, \quad \pi^j_{Fnt} = \frac{(d^j_{Fn}P^F_{jt})^{1-\sigma}}{\sum_{m'=1}^{N}(d^j_{m'n}\tilde{c}_{m'jt})^{1-\sigma} + (d^j_{nF}P^F_{jt})^{1-\sigma}}, \quad \text{(C.11)}$$

$$\text{EX}_{njt} = (d^j_{nF}\tilde{c}_{njt})^{1-\sigma}D^F_{jt}. \quad \text{(C.12)}$$

Given the data on region-sector gross output, GO_{njt}, sectoral exports, EX_{jt}, sectoral imports, IM_{jt}, and the parametrized trade costs, d^j_{mn} and d^j_{Fn}, the above system of equations holds for each j and t. The above system of equation has $N+2$ number of equations with the same number of unknowns, $\{\tilde{c}_{njt}, P^F_{jt}, D^F_{jt}\}^{N,J}_{n=1,j=1}$, for each period and the system of equation is exactly identified up to scale. Without loss of generality, I re-express P^F_{jt}. D^F_{jt}, and $\tilde{c}_{njt}$ relative to the unit cost of the reference region for each j and t: $\bar{c}_{njt} = \tilde{c}_{njt}/\tilde{c}_{n_0jt}$, $\bar{P}^F_{jt} = P^F_{jt}/\tilde{c}_{n_0jt}$, and $\bar{D}^F_{jt} = D^F_{jt}/\tilde{c}^{1-\sigma}_{n_0jt}$, where n_0 denotes the reference region. Then, I solve for $\bar{c}_{njt}$, $\bar{P}^F_{jt}$, and $\bar{D}^F_{jt}$.

- Step 2. Using the backed-out $\{\bar{c}_{njt}, \bar{P}^F_{jt}, \bar{D}^F_{jt}\}^{N,J,02}_{n=1,j=1,t=98}$ for each sector and period, I can compute region-to-region trade shares and region-sector import shares from equation (C.11) and regions-sector exports from equation (C.12).

C.6.2 Calibration of Shocks

I back out the shocks using the following algorithm.

Data input.

- Backed out $\{\bar{c}_{njt}, \bar{P}^F_{jt}, \bar{D}^F_{jt}\}^{N,J,02}_{n=1,j=1,t=97}$ from step 2 in Section C.6.1
- Sector PPI growth $\{\widehat{\text{PPI}}_{jt}\}^{J,02}_{j=1,t=98}$
- Aggregate real GDP growth, 1998-2002
- Region-sector employment shares $\{\lambda_{njt}\}^{N,J,02}_{n=1,j=1,t=97}$
- Population distributions $\{L_{nt}\}^{N,02}_{n=1,t=97}$
- Initial allocation in 1997 required for the dynamic hat algebra described in Section C.5

Algorithm. I use the following algorithm to back out $\{\hat{A}_{njt}, \hat{b}_{nt}, \hat{E}_{njt}, \hat{P}^F_{jt}, \hat{D}^F_{jt}\}^{N,J,T}_{n=1,j=1,t=98}$.

- Step 1. Guess $\{\hat{A}^{(0)}_{njt}, \hat{b}^{(0)}_{nt}, \hat{E}^{(0)}_{njt}\}^{N,J,02}_{n=1,j=1,t=98}$.
- Step 2. Based on the guess, set future sequences of shocks after 2003:

$$\hat{A}^{(0)}_{njt} = 1/\Big(\prod^{02}_{\tau=98} \hat{A}^{(0)}_{nj\tau}\Big)^{\frac{1}{25}}, \forall t \in \{03, \ldots, 28\} \text{ and } \hat{A}^{(0)}_{njt} = 1, \forall t \in \{29, \ldots, T\}$$

$$\hat{E}^{(0)}_{njt} = 1/\Big(\prod^{02}_{\tau=98} \hat{E}^{(0)}_{nj\tau}\Big)^{\frac{1}{25}}, \forall t \in \{03, \ldots, 28\} \text{ and } \hat{E}^{(0)}_{njt} = 1, \forall t \in \{29, \ldots, T\}$$

$$\hat{b}^{(0)}_{nt} = 1/\Big(\prod^{02}_{\tau=98} \hat{b}^{(0)}_{n\tau}\Big)^{\frac{1}{25}}, \forall t \in \{03, \ldots, 28\} \text{ and } \hat{b}^{(0)}_{nt} = 1, \forall t \in \{29, \ldots, T\}$$

$$\hat{D}^{F,(0)}_{jt} = 1/\Big(\prod^{02}_{\tau=98} \hat{D}^{F,(0)}_{j\tau}\Big)^{\frac{1}{25}}, \forall t \in \{03, \ldots, 28\} \text{ and } \hat{D}^{F,(0)}_{jt} = 1, \forall t \in \{29, \ldots, T\}$$

$$\hat{P}^{F,(0)}_{jt} = 1/\Big(\prod^{02}_{\tau=98} \hat{P}^{F,(0)}_{j\tau}\Big)^{\frac{1}{25}}, \forall t \in \{03, \ldots, 28\} \text{ and } \hat{P}^{F,(0)}_{jt} = 1, \forall t \in \{29, \ldots, T\}$$

- Step 3. Given the guess, solve the model using the algorithm described in Section C.5.
- Step 4. Update a guess of relative productivity of each sector relative to the reference region n_0: $\{\hat{A}^{(0)}_{njt}/\hat{A}^{(0)}_{n_0jt}\}^{N,J,02}_{n=1,j=1,t=98}$ based on the following steps.
  1. Using $\{\bar{c}_{njt}\}^{N,J,02}_{n=1,j=1,t=97}$ from step 2 in Section C.6.1, compute $\{\hat{\bar{c}}^{\text{data}}_{njt}\}^{N,J,02}_{n=1,j=1,t=98}$ in changes. In the model, also compute the corresponding object $\{\hat{\bar{c}}^{(0)}_{njt}\}^{N,J,02}_{n=1,j=1,t=98}$ in changes. Note that $\hat{\bar{c}}^{(0)}_{n_0jt} = \hat{\bar{c}}^{\text{data}}_{n_0jt} = 1$ for all sectors in the reference region n_0.

2. Adjust $\hat{A}^{(0)}_{njt}/\hat{A}^{(0)}_{n_0jt}$ and iterate steps 2-3 until the gap between $\{\hat{c}^{(0)}_{njt}\}^{N,J,02}_{n=1,j=1,t=98}$ and $\{\hat{c}^{\text{data}}_{njt}\}^{N,J,02}_{n=1,j=1,t=98}$ is smaller than the specified threshold ε.

- Step 5. Update a guess of each region's productivity of the reference sector relative to the reference region n_0: $\{\hat{A}^{(0)}_{nj_0t}/\hat{A}^{(0)}_{n_0j_0t}\}^{N,J,02}_{n=1,j=1,t=98}$ based on the following steps.
  1. Compute sectoral PPI growth (equation (C.1) in the model, and compare it with the data. Note that PPI growth in the data identifies only relative price growth relative to the reference sector j_0. So, I compare $\{\widehat{PPI}_{jt}/\widehat{PPI}_{j_0t}\}^{J,02}_{j=1,t=98}$ to the corresponding object in the data $\{\widehat{PPI}^{\text{data}}_{jt}/\widehat{PPI}^{\text{data}}_{j_0t}\}^{J,02}_{j=1,t=98}$.
  2. Adjust the reference region n_0's sectoral productivity relative to the reference sector j_0, $\{\hat{A}^{(0)}_{n_0jt}/\hat{A}^{(0)}_{n_0j_0t}\}^{J,02}_{j=1,t=98}$ and iterate previous steps 2-4 until the gap between $\{\widehat{PPI}_{jt}/\widehat{PPI}_{j_0t}\}^{J,02}_{j=1,t=98}$ of the model and the data is smaller than ε.
- Step 6. The remaining unpinned productivity component is productivity changes of the reference sector j_0 in the reference region n_0: $\{\hat{A}_{n_0j_0t}\}^{02}_{t=98}$.
  1. Adjust $\{\hat{A}^{(0)}_{n_0j_0t}\}^{02}_{t=98}$ and iterate previous steps 2-5 until the gap between aggregate real GDP growth of the model (equation (C.2)) and the data is smaller than ε.
  2. Once I recover $\hat{c}_{n_0jt}$ of the reference region, I recover the absolute levels of $\hat{P}^F_{jt}$ and $\hat{D}^F_{jt}$ by computing $\hat{D}^F_{jt} = \hat{c}^{1-\sigma}_{n_0jt}\hat{\tilde{D}}^F_{jt}$ and $\hat{P}^F_t = \hat{C}_{n_0jt}\hat{\tilde{P}}^F_{jt}$.
- Step 7. Update labor supply shocks $\{E^{(0)}_{njt}\}^{N,J,02}_{n=1,j=1,t=98}$.
  1. Compare $\{\hat{\lambda}^{(0)}_{njt}\}^{N,J,02}_{n=1,j=1,t=98}$ computed from the model to $\{\hat{\lambda}^{\text{data}}_{njt}\}^{N,J,02}_{n=1,j=1,t=98}$ obtained from the data.
  2. Adjust $\{\hat{E}^{(0)}_{njt}\}^{N,J,02}_{n=1,j=1,t=98}$ and iterate previous steps 2-6 until $|\hat{\lambda}^{(0)}_{njt} - \hat{\lambda}^{\text{data}}_{njt}| < \varepsilon$.
- Step 8. Update $\{\hat{b}^{(0)}_{nt}\}^{N,02}_{n=1,t=98}$. Because $\hat{b}_{nt}$ is identified up to normalization, I normalize $\hat{b}_{n_0t} = 1$ for the reference region n_0.
  1. Compare $\{\hat{L}^{(0)}_{nt}\}^{N,02}_{n=1,t=98}$ computed from the model to $\{\hat{L}^{\text{data}}_{nt}\}^{N,02}_{n=1,t=98}$ from the data.
  2. Adjust $\{\hat{b}^{(1)}_{nt}\}^{N,02}_{n=1,t=98}$ and iterate previous steps 2-8 until $|L^{(0)}_{nt} - L^{\text{data}}_{nt}| < \varepsilon$.
- Step 9. Repeat steps 2-8 until convergence.

C.7 Intertemporal Investment in Capital

Model. In this section, I extend the model to incorporate dynamic investment in capital following Kleinman et al. (2021). I introduce new agents, landlords, who are immobile across regions. Landlords in each region can produce one unit of capital using one unit of final goods. They choose their consumption and investment to maximize their intertemporal utility:

$$v^k_{nt} = \sum_{s=t_0}^{\infty} \beta^{t+s} \frac{(C^k_{n,t+s})^{1-\frac{1}{\phi}}}{1-\frac{1}{\phi}}, \tag{C.13}$$

subject to budget constraints: $r_{nt}K_{nt} = P_{nt}(C^k_{nt} + K_{n,t+1} - (1-\delta)K_{nt})$, where r_{nt} is the rental rate of capital. $r_{nt}K_{nt}$ is total income from existing capital stock, $P_{nt}C^k_{nt}$ is total value of their consumption, and $P_{nt}(K_{n,t+1} - (1-\delta)K_{nt})$ is total value of their investment.

Capital is an input to production. Production function is given as

$$q_{njt} = A_{njt} H_{njt}^{\gamma_j^H} K_{njt}^{\gamma_j^K} \prod_{k=1}^{J} (M_{njt}^k)^{\gamma_j^k}, \qquad \gamma_j^H + \gamma_j^K + \sum_k \gamma_j^k = 1.$$

Capital stock is freely mobile across sectors within regions, but immobile across regions, which is interpreted as physical structure such as factories.

Their optimal investment decisions are characterized by the following law of motion for capital:

$$K_{n,t+1} = (1 - \zeta_{nt}) R_{nt} K_{nt}, \tag{C.14}$$

where $R_{nt} = 1 - \delta + r_{nt}/P_{nt}$ is the gross return on capital and ζ_{nt} is recursively defined as

$$\zeta_{nt}^{-1} = 1 + \beta^{\phi} \left(R_{n,t+1}^{\frac{\phi-1}{\phi}} \zeta_{n,t+1}^{-\frac{1}{\phi}} \right)^{\phi}.$$

Landlords save fractions of $(1-\zeta_{nt})$ out of current-period wealth $R_{nt}K_{nt}$. The optimal consumption of region n's landlords satisfies $C_{nt}^k = \zeta_{nt} R_{nt} K_{nt}$. Capital stock, as well as population, is a state variable.

Capital market clearing requires that landlords' capital income equal rental payments for its use. Cost-minimization of intermediate goods producers and the zero profit condition imply that the capital market clearing condition is

$$r_{nt} = \frac{\sum_{j=1}^{J} (\gamma_j^K / \gamma_j^H) W_{njt} H_{njt}}{K_{nt}}.$$

Capital market clearing implies that capital evolves according to

$$K_{nj,t+1} = \left(\frac{(\gamma_j^K/\gamma_j^H) \hat{W}_{nj,t+1} \hat{H}_{nj,t+1} W_{njt} H_{njt}}{\sum_{k=1}^{J} (\gamma_k^K/\gamma_k^H) \hat{W}_{nk,t+1} \hat{H}_{nk,t+1} W_{nkt} H_{nkt}} \right) K_{n,t+1}$$

The equilibrium with capital accumulation is defined as follows.

Definition 2. *Given the parameters of the model, $\{\boldsymbol{\Psi}_t\}_{t=t_0}^{\infty}$, $\{\boldsymbol{\tau}_t\}_{t=t_0}^{\infty}$, and initial allocations of the state variables $\{L_{nt_0}, K_{nt_0}\}_{n=1}^{N}$, the competitive equilibrium of the model is the set of population, sectoral allocation of workers, wages, working hours, expected lifetime utilities, rental rate of capital, and capital stock $\{L_{nt}, \lambda_{njt}, W_{njt}, h_{nt}, V_{nt}, r_{nt}, K_{n,t+1}\}_{n=1,j=1,t=t_0}^{N,J,\infty}$ that satisfies the following condition for each region n, each sector j, and all periods t: (i) Given $\{W_{njt}\}_{n=1,j=1}^{N,J}$, households optimally choose their working hours and allocate their workers across different sectors; (ii) $\{V_{nt}\}_{n=1}^{N}$ satisfies equation (4.11); (iii) $\{L_{nt}\}_{n=1}^{N}$ evolves according to equation (4.13); (iv) $\{K_{n,t+1}\}_{n=1}^{N}$ evolves according to equation (C.14); and (v) goods, labor, and capital market clearing conditions are satisfied.*

Algorithm. With the additional data on region-sector capital stock, I use the following algorithm for solving the model. See Kleinman et al. (2021) for more details on the algorithm and data inputs required to solve the model.

- Step 1. Guess paths of $\{\hat{u}_{nt}^{(0)}\}_{t=t_0+1}^{T+1}$ and $\{\zeta_{nt}^{(0)}\}_{t=t_0+1}^{T+1}$ for a sufficiently large T. The paths converge at $T+1$, so set $\hat{u}_{n,T+1}^{(0)} = 1$.
- Step 2. Based on the guessed consumption rates and observed allocation of capital $\{K_{nt_0}\}$ and $\{K_{n,t_0+1}\}$, set the gross return of capital at time t_0 as follows:

$$R_{nt_0} = \frac{K_{n,t_0+1}}{K_{nt_0}}(1-\zeta_{nt_0}^{(0)}).$$

- Step 3. Given the initial allocation of migration shares $\{\mu_{nmt_0}\}$, using the guessed $\{\hat{u}_{nt}^{(0)}\}_{t=t_0+1}^{T+1}$, compute paths of migration shares $\{\mu_{nmt}\}_{t=t_0+1}^{T+1}$. Using the computed migration shares $\{\mu_{nmt}\}_{t=1}^{T+1}$, compute population for periods $t \geq t_0+1$. Conditional on implied $\hat{L}_{n,t+1}$, $\hat{K}_{n,t+1}$, and allocation in period t, solve for $\{\hat{W}_{njt}\}$ that satisfy the system of equations of the static equilibrium in Section C.4 for each t.
- Step 4. Compute the next period gross return on capital $R_{n,t+1}$[18]:

$$R_{n,t+1} = (1-\delta) + \frac{\hat{W}_{nj,t+1}\hat{H}_{nj,t+1}}{\hat{P}_{n,t+1}\hat{K}_{nj,t+1}}(R_{nt} - (1-\delta)).$$

  Because of cost minimization, the above expression holds for any $j \in \mathcal{J}$.
- Step 5. Using the next period gross return on capital $R_{n,t+1}$ and guessed $\zeta_{n,t+1}^{(0)}$, compute capital $K_{n,t+2}$ in period $t+2$:

$$K_{n,t+2} = (1-\zeta_{n,t+1}^{(0)})R_{n,t+1}K_{n,t+1}.$$

- Step 6. For each t, solve backward for $\{\hat{u}_{nt}^{(1)}\}_{t=t_0+1}^{T+1}$.
- Step 7. For each t, solve backward for $\{\zeta_{nt}^{(1)}\}_{t=1}^{T+1}$:

$$\zeta_{nt}^{(1)} = \frac{\zeta_{n,t+1}^{(0)}}{\zeta_{n,t+1}^{(0)} + \beta^{\psi} R_{n,t+1}^{\psi-1}},$$

  where $R_{n,T+1} = 1/\beta$ is imposed.
- Step 8. Take $\{(1-\omega)\hat{u}_{nt}^{(0)} + \omega\hat{u}_{nt}^{(1)}\}_{t=t_0+1}^{T+1}$ and $\{(1-\omega)\zeta_{nt}^{(0)} + \omega\zeta_{nt}^{(1)}\}_{t=t_0+1}^{T+1}$ for some weight $\omega \in (0,1]$, and return to Step 2.
- Step 9. Continue until both $\{\hat{u}_{nt}^{(1)}\}$ and $\{\zeta_{nt}^{(1)}\}$ converge.

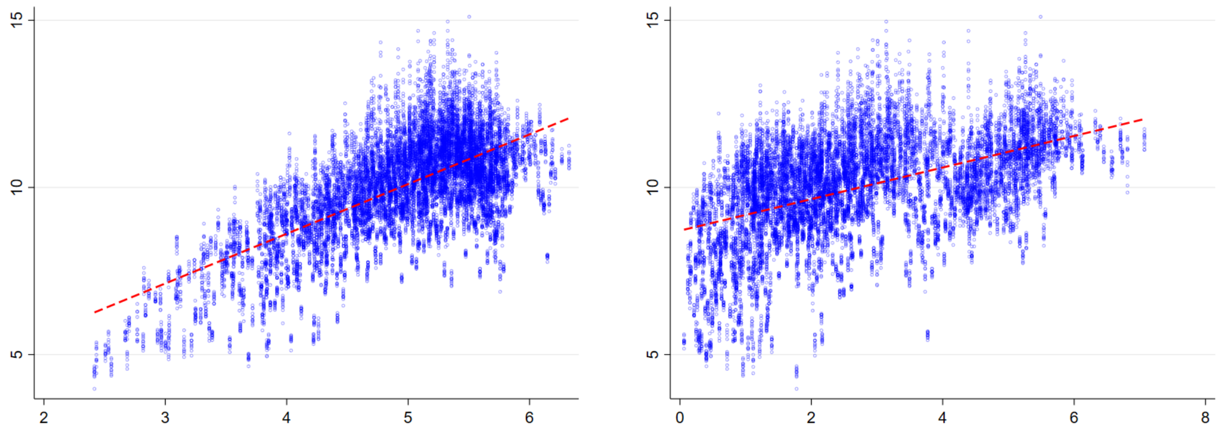
Calibration. I set labor shares of value added to 1/3 for all sectors: $\frac{\gamma_j^H}{\gamma_j^H+\gamma_j^k} = 1/3$. I set the intertemporal elasticity of substitution of landlords to 1 ($\phi = 1$) following Kleinman et al. (2021). The remaining parameters are set to the baseline values in Table 4.

[18] Because $R_{n,t+1} \equiv (1-\delta) + \frac{r_{n,t+1}}{P_{n,t+1}}$, $\frac{R_{n,t+1}-(1-\delta)}{R_{nt}-(1-\delta)} = \frac{\hat{r}_{n,t+1}}{\hat{P}_{n,t+1}}$ holds. The cost minimization implies that $\frac{\hat{W}_{nj,t+1}\hat{H}_{nj,t+1}}{\hat{r}_{n,t+1}\hat{K}_{nj,t+1}} = 1, \forall j \in \mathcal{J}$. Substituting $\hat{r}_{n,t+1}$ by $\hat{W}_{nj,t+1}\hat{H}_{nj,t+1}/\hat{K}_{nj,t+1}$ in $\frac{R_{n,t+1}-(1-\delta)}{R_{nt}-(1-\delta)} = \frac{\hat{r}_{n,t+1}}{\hat{P}_{n,t+1}}$, we can obtain that $R_{n,t+1} = (1-\delta) + \frac{\hat{W}_{nj,t+1}\hat{H}_{nj,t+1}}{\hat{P}_{n,t+1}\hat{K}_{nj,t+1}}(R_{nt} - (1-\delta))$.

Quantitative Results. Panel C of Table C9 reports the quantitative results. The results are qualitatively similar to the baseline results but with lower magnitude, because labor plays a less important role in production ($\gamma_j^H = 0.66$) and capital slowly adjusts over time.

C.8 Additional Figures and Tables

Figure C11: Correlates of the Inferred Migration Frictions



A. Log distance B. Index for regional conflicts

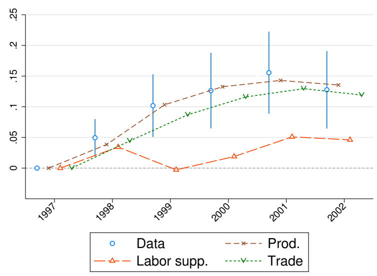
Notes. Panels A and B are scatter plots between the inferred migration frictions and log distance and the index for regional conflicts, respectively. The red dashed lines are the corresponding linear fits.

Table C9: Robustness. Aggregate Real GDP Growth after the Crisis

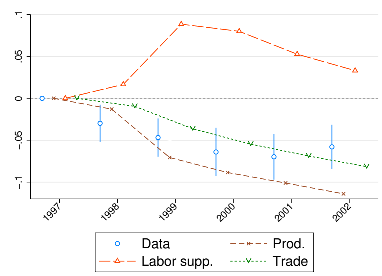
	Δ No-mobility -Baseline	Δ Free-mobility -Baseline	Δ Decrease med. -Baseline (common)	(directional)
	(1)	(2)	(3)	(4)
	Δ Cumulative growth ($\prod_{\tau=98}^{02} Y_\tau^r$) *(p.p.)*			
Main Calibration	−0.32	4.35	0.02	0.15
	Panel A			
Permanent changes in $\hat{m}_{nmt}$	−0.32	4.24	0.03	0.12
	Panel B			
No amenity shocks	−0.39	3.98	0.0	0.11
	Panel C			
Capital accumulation	−0.25	0.52	0.01	0.09

Notes. This table reports differences of cumulative real GDP growth during 1997-2001 between the baseline and the counterfactuals. Panels A, B, and C report results of the extended model with capital accumulation, permanent changes in migration frictions, and the model without amenity shocks.

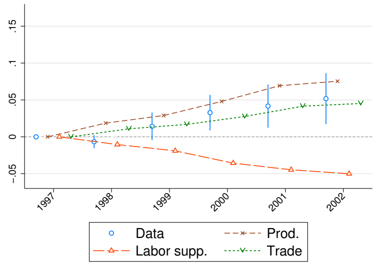
Figure C12: Robustness. Shutting off Specified Shocks. Role of Individual Shocks. Event Study. Migration and Employment Responses to the Crisis



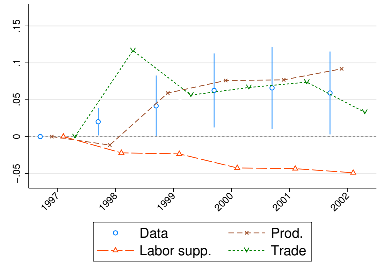
A. Migration inflow



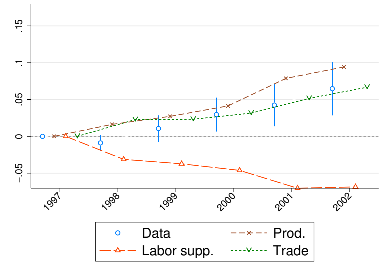
B. Migration outflow



C. Total emp



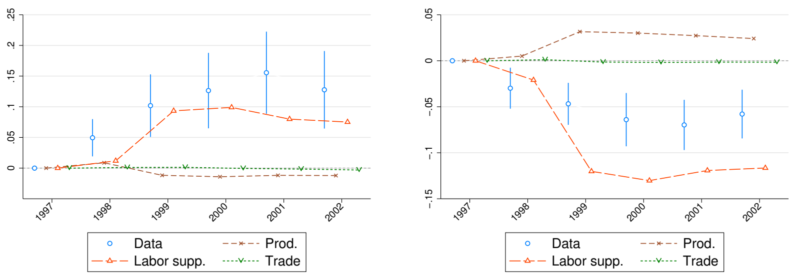
D. Top 5 emp



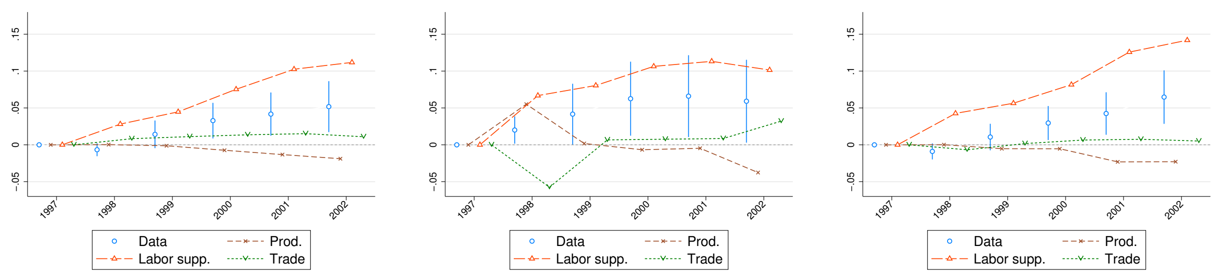
E. Non-top 5 emp

Notes. The figure plots the estimates of the migration and employment event-study coefficients when shutting off a set of specified shocks at a time. In Panels A, B, C, D, and E, the dependent variables are log migration inflow, log migration outflow, log total employment, top 5 employment, and non-top 5 employment, respectively. The blue circle represents the estimated event study coefficients from the data, with the 95% confidence intervals (Figures 2 and 3). The brown dashed, red long-dashed, and green dotted-lines represent the event-study coefficients when shutting off productivity, labor supply, and trade-related shocks, respectively

Figure C13: Robustness. Feeding in Specified Shocks. Role of Individual Shocks. Event Study. Migration and Employment Responses to the Crisis



A. Migration inflow B. Migration outflow



C. Total emp D. Top 5 emp E. Non-top 5 emp

Notes. The figure plots the estimates of the migration and employment event-study coefficients when feeding in only a set of specified shocks at a time. In Panels A, B, C, D, and E, the dependent variables are log migration inflow, log migration outflow, log total employment, top 5 employment, and non-top 5 employment, respectively. The blue circle represents the estimated event study coefficients from the data, with the 95% confidence intervals (Figures 2 and 3). The brown dashed, red long-dashed, and green dotted-lines represent the event-study coefficients when feeding in productivity, labor supply, and trade-related shocks, respectively

Table C10: Robustness. Sensitivity Analysis. Aggregate Real GDP Growth after the Crisis

	Δ No-mobility - Baseline	Δ Free-mobility - Baseline	Δ Decrease med. - Baseline (common)	(directional)
	(1)	(2)	(3)	(4)
	Δ Cumulative growth ($\prod_{\tau=98}^{02} Y_\tau^r$) *(p.p.)*			
Main Calibration	−0.32	4.35	0.02	0.15
	Panel A. Elasticity of substitution			
Low, $\sigma = 2$	−0.29	3.27	0.02	0.14
High, $\sigma = 6$	−0.34	5.16	0.03	0.17
	Panel B. Migration elasticity $1/\nu$			
Low, $1/\nu = 0.3$	−0.32	2.0	0.02	0.13
High, $1/\nu = 0.75$	−0.32	6.23	0.03	0.16
	Panel C. Sectoral labor supply elasticity θ			
Low, $\theta = 1.05$	−0.33	4.68	0.03	0.16
High, $\theta = 2$	−0.33	4.10	−0.00	0.14
	Panel D. Aggregate labor supply elasticity			
Low, $\psi = 0$	−0.29	8.53	0.05	0.30
High, $\psi = 1.5$	−0.30	1.93	0.02	0.10

Notes. This table reports differences of cumulative real GDP growth during 1997-2001 between the baseline and the counterfactuals under alternative parametrization.