

# Internal Migration Adjustment and Recovery from Large Crises\*

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## Abstract

This paper studies internal migration adjustments during the South Korean crisis of 1997-1998, and their aggregate and regional impacts on ensuing recovery. 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 of migration to quantify the contributions of migration adjustment 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. Higher mobility raises sectoral labor reallocation and aggregate real GDP growth, while making the spatial distribution of production more 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

*JEL Codes:* F16, F31, R23

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# 1 Introduction

In the aftermath of large crises, economies typically experience sharp contractions in economic activities and abrupt trade adjustments, disproportionately affecting different sectors (e.g. tradable vs. non-tradable). The uneven sectoral impacts, coupled with regional variation in industrial composition, suggest that migration across regions at the onset of crises can potentially boost output, smooth out adverse shocks, and foster post-crisis recovery.

This paper studies how internal migration adjusted following the South Korean crisis of 1997-1998 and its aggregate and regional impacts on subsequent recovery. The contributions of this study are twofold. First, it provides novel empirical evidence on migration adjustments post-crisis, showing that people moved more frequently to regions specializing in sectors that experienced significant expansion during the recovery, resulting in increased total employment in these regions. Second, it develops a model to quantify the effects of the migration channel on the recovery.

Exploiting cross-sectional variation in industrial composition, I empirically document how migration and employment responded to local labor market shocks induced by the crisis. Employing a long-difference specification, 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 changes in gross output. 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 empirical 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, and where to live. Migration decisions are modeled as dynamic discrete choices. They choose locations based on real income, the 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 are the most critical factor in replicating these findings. When labor supply shocks are turned off, the model fails to replicate the findings.

Using the calibrated model, I assess how the economy would have adjusted differently in response to the crisis depending on varying levels of migration mobility. I compare the transition paths of the baseline economy, where migration mobility aligns with observed flows in the data, with those of counterfactual economies, which have different migration mobility levels from the baseline. 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 1998-2001 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 were 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.

In emerging market economies, large crises occur more frequently, but the migration channel is often less effective due to higher migration frictions.<sup>1</sup> The quantitative findings suggest that migration policies could be a viable option for policymakers in these economies to stimulate post-crisis recoveries. While the framework does not explicitly incorporate the monetary costs of increasing mobility, the calculated GDP effects provide useful bounds for policymakers to assess whether a policy aimed at improving mobility is worth pursuing during post-crisis recoveries.

**Related literature** This paper contributes to several strands of literature. First, it contributes to the literature on the consequences of large crises (see among many others, [Aguilar, 2005](#); [Burststein](#)

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<sup>1</sup>For example, [Bryan and Morten \(2019\)](#) document higher internal migration frictions in Indonesia than in the US. See [Tombe and Zhu \(2019\)](#) for the Hukou system in China.

et al., 2005, 2007; Alessandria et al., 2010; Pratap and Urrutia, 2012; Gopinath and Neiman, 2014; Kim, 2014; Kim et al., 2015; Chaney, 2016; Drenik, 2016; Cravino and Levchenko, 2017; Blaum, forthcoming; Drenik et al., 2018; Alessandria et al., 2015; Ates and Saffie, 2021; Blanco et al., 2022b; Auer et al., 2022). This paper provides novel evidence on how internal migration adjusted to the crisis and quantifies its effects on the subsequent recovery, with a focus on regional heterogeneity. Previous studies, such as Kohn et al. (2020) and Queralto (2020), document sluggish recoveries after crises due to financial frictions and declines in innovation efforts, respectively. This paper shows that migration frictions can be another channel for such sluggish recovery.

Second, this paper relates to the quantitative spatial and trade literature on internal migration frictions (see among many others, Monte et al., 2018; Morten and Oliveira, 2018; Eckert, 2019; Fan, 2019; Hao et al., 2020; Ma and Tang, 2020; Gai et al., 2021; Pellegrina and Sotelo, 2021; Giannone et al., 2023; Imbert et al., 2023; Lagakos et al., 2023; Adamopoulos et al., 2024). Bryan and Morten (2019) and Tombe and Zhu (2019) study spatial misallocation and long-run TFP losses due to migration frictions in a static setting. This paper explores how migration frictions affect the transitional reallocation process after the crisis in a dynamic setting building on the dynamic spatial models with discrete choices developed by Artuc et al. (2010) and Caliendo et al. (2019).

Third, this paper contributes to the empirical literature on internal migration adjustments to local labor market conditions, pioneered by Blanchard and Katz (1992) and further developed by many others (see among many others Autor et al., 2013; Monras, 2020a,b; Cadena and Kovak, 2016; Hakobyan and McLaren, 2016; Dix-Carneiro and Kovak, 2017; Kondo, 2018; Dix-Carneiro and Kovak, 2019; Benguria et al., 2018; Greenland et al., 2019; Jauer et al., 2019; Adão et al., 2020; Imbert and Papp, 2020). Many previous studies have primarily focused on more persistent local labor shocks, such as long-run Bartik shocks, commodity super-cycles, the China shock, policy reforms, and trade liberalization episodes. Exceptions are Saks and Wozniak (2011), Fogli et al. (2012), Dao et al. (2017), and House et al. (2018, 2020) who study migration responses to business cycle frequency shocks in the US. Monras (2020a) study how internal migration dissipated heterogeneous local shocks due to the Great Recession in the US. This paper examines short-run migration adjustments to local shocks induced by the crisis in an emerging market economy.

**Structure** The structure of this paper is as follows. Section 2 describes the data used for the empirical and quantitative analyses and the background on the South Korean crisis. Section 3 presents empirical evidence on migration and employment adjustments after the crisis. Section 4 presents the quantitative model and describes 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 district and 15 sectors, ensuring that each region has positive employment for all 15 sectors. Appendix A describes the construction of the final dataset in details.

I construct region-sector employment shares from the Census on Establishment which covers the universe of formal establishments with one or more employees at a finely disaggregated geographic level for all sectors. On average, approximately 2.9 million establishments are covered by this dataset across the sample period. Employment shares are computed by summing up employment across establishments within region-sectors and dividing by total regional employment. 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 reported in the KLEMS database. Appendix Figure A8 reports coverage by sector.

I construct region-sector gross output by combining the Census of Establishment, and state-sector level gross output, and the IO tables from the WIOD 2013 release (Timmer et al., 2015). National sectoral gross output is allocated to 16 states using state-sector level 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 origin and destination divided by lagged population of origin. The sample is restricted to individuals aged 20 to 55 to focus on working-age population. I obtain sectoral import and export data and IO tables from the WIOD and, before 1995, from 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. I obtain region-level residential housing price and consumer price index (CPI) data from Statistics Korea.

**Descriptive statistics** Table 1 presents the descriptive statistics of the final dataset. The average employment shares in the overall and the 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%. This rate is approximately 1 percentage point higher than the annual inter-county migration rates reported in Molloy et al. (2011).

Table 1: Descriptive Statistics

Variable	Mean	SD	Median
Overall mfg. emp share	0.28	0.13	0.24
Top 5 export-intensive mfg. emp 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 and 2002.

## 2.2 Stylized Facts

In late 1997, South Korea was hit by a crisis and the government requested for a bailout package from the IMF. In 1998, the country experienced a sharp contraction of economic activity, with GDP growth dropping to  $-5.8\%$  from  $5.2\%$  in 1997, 11 percentage points decline, and the real exchange rate depreciating by 26%. Between 1998-2001, the economy recovered with real GDP growth rebounding to pre-crisis levels, and 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 the share of exports to gross output. Manufacturing sectors tended to have higher export intensity and export shares. Based on the export intensities, I define the top 5 most export-intensive manufacturing sectors.<sup>2</sup>

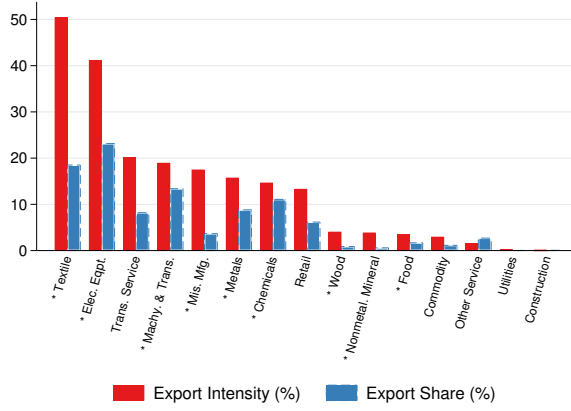
With the 26% depreciation in the real exchange rate, the aggregate export intensity soared from 15% in 1997 to 19% in 1998, remaining approximately 2 percentage points higher in the subsequent years (Panel B). This aggregate increase is primarily attributed to heightened export intensities of the top 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 expansion (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.

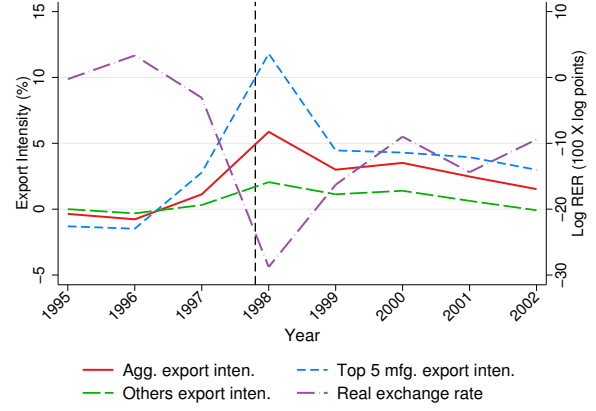
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<sup>2</sup>The top 5 sectors include textiles, electrical equipment, machinery and transportation equipment, metals, and chemicals. The miscellaneous manufacturing sector, despite having higher export intensity than some included sectors, was not classified among the top 5 due to its low export shares and ambiguous classification.

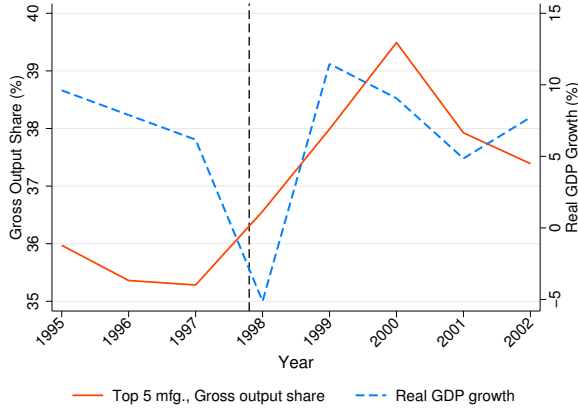
Figure 1. Stylized Facts after the South Korean Crisis



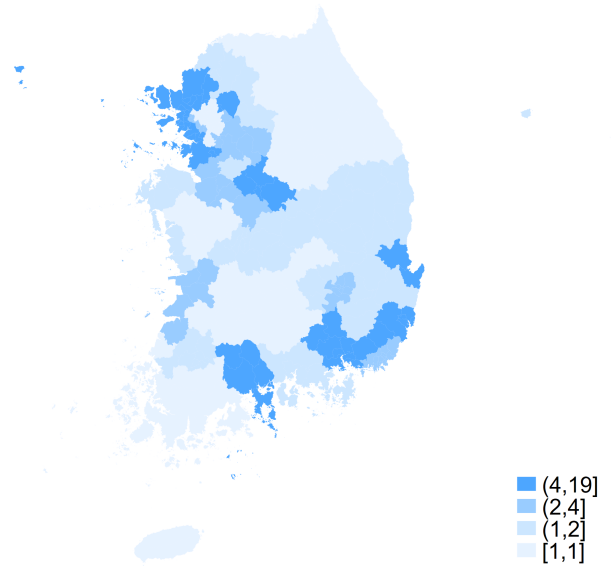
A. Sectoral Heterogeneity in export intensity



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

**Fact 3. Regional heterogeneity in industrial composition** The top 5 sectors were geographically concentrated in a few regions (Panel D), which illustrates regional variation in the top 5

employment shares. These sectors were 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 a notable contribution from more export-intensive sectors. This was partly due to their export expansion, 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 expansion 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 on Migration and Employment Responses to the Crisis

#### 3.1 Migration Flow

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

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

Dependent variables are changes in log migration flows from region  $n$  to  $m$ , defined as a share of total migrants from region  $n$  to  $m$  to lagged population in  $n$ .  $\text{Bartik}_m$  is a standardized Bartik local labor market shock, which will be discussed below.  $\mathbf{X}_n$  is region  $n$ 's observables.  $\delta_n$  are regional fixed effects.  $\epsilon_{nm}$  are the error terms. Any time-invariant pair characteristics, such as distance, are differenced out. Standard errors are clustered at the origin and the 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.<sup>3</sup> Zero observations are not an issue because only 2 out of 2916 observations are dropped due to zero values.

The Bartik shock is computed as the employment-weighted sectoral growth of gross output excluding region  $n$ 's gross output between 1997-2000:

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

$\Delta \text{Gross Output}_{(-n)j,00}$  captures sector  $j$  common components unrelated to regions' characteristics such as sector-common productivity shocks or export expansion during the recovery. Higher values of the Bartik shock imply that regions initially had higher employment shares in sectors that expanded

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<sup>3</sup>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.



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

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
<i>Panel A. Dep. <math>\Delta</math> Migration inflow</i>									
Bartik <sub>m</sub>	0.11*** (0.04)	0.11*** (0.04)	0.11*** (0.04)	0.12*** (0.04)	0.10*** (0.03)	0.10*** (0.03)	0.11*** (0.03)	0.10*** (0.04)	0.09** (0.03)
Adj. $R^2$	0.22	0.22	0.22	0.22	0.25	0.24	0.25	0.24	0.28
<i>Panel B. Dep. <math>\Delta</math> Migration outflow</i>									
Bartik <sub>n</sub>	-0.03* (0.02)	-0.05*** (0.01)	-0.03* (0.02)	-0.04** (0.02)	-0.03** (0.01)	-0.03* (0.01)	-0.04*** (0.01)	-0.03* (0.02)	-0.04*** (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	2914	2914	2914	2914	2914	2914	2914	2914	2914

**Note.** Standard errors are in parenthesis. \*:  $p < 0.1$ ; \*\*:  $p < 0.05$ ; \*\*\*:  $p < 0.01$ . Standard errors are clustered at the destination and the 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  $\Delta \ln \mu_{nm} = \beta \text{Bartik}_m + \mathbf{X}'_m \gamma + \delta_n + \epsilon_{nm}$  and  $\Delta \ln \mu_{nm} = \beta \text{Bartik}_n + \mathbf{X}'_n \gamma + \delta_m + \Delta \epsilon_{nm}$ , respectively, weighted by the initial population of origin regions in 1994. Dependent variables are changes in log migration flows between 1997-2000. Bartik<sub>n</sub> is the standardized Bartik shock (equation (3.2)). Controls included are: log initial employment (column 2), pretrends in migration flows between 1995 and 1996 (column 3), regional exposure to balance sheet effects (column 4), changes in log unemployment rate (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. All specifications include origin and destination fixed effects. All specifications of Panels A and B include origin and destination fixed effects, respectively.

more 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 observables. 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, following [Dix-Carneiro and Kovak \(2017\)](#). The results remain stable after including these additional variables.

Previous studies, such as [Aguilar \(2005\)](#), [Kim et al. \(2015\)](#), and [Queralto \(2020\)](#), have documented balance sheet effects due to currency depreciations and foreign debt compositions. To capture regional exposure to these effects, I construct a variable using the same data and a similar measure proposed by [Kim et al. \(2015\)](#), who examined the negative balance sheet effects on South Korean firms. Including this variable in column 4 does not alter the results, 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 the log regional unemployment rates between 1995-2000, obtained from Population Census, and the Bartik coefficient remains stable.<sup>4</sup>

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 the differences in industrial composition between two regions using the Mahalanobis distance of the initial employment shares between these regions.<sup>5</sup> Second, I construct an index of regional conflicts based on the Mahalanobis distance in candidates' vote shares in the 1992 presidential election, which serves as a proxy for cultural, economic, and political conflicts between regions.<sup>6</sup> Lastly, I include log bilateral distance.

Concerns about omitted variable bias can arise if housing prices or amenities respond to the local labor shocks (e.g. [Saiz, 2010](#); [Diamond, 2016](#)). 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 price 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.<sup>7</sup>

In column 9, I control for all additional variables jointly. The estimates remain within one standard

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<sup>4</sup>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.

<sup>5</sup>For example, [Artuc et al. \(2010\)](#), [Dix-Carneiro \(2014\)](#), and [Traiberman \(2019\)](#) have documented sizable mobility costs across sectors and occupations.

<sup>6</sup>See Appendix B.1 for more details on institutional setting behind the index of regional conflicts.

<sup>7</sup>This includes the number of retail establishments per capita, the number of education service establishments per capita, shares of workers using public transportation, the 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).

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.<sup>8</sup> 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.<sup>9</sup> 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, as studied by Goldsmith-Pinkham et al. (2020).<sup>10</sup> The Rotemberg 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 the top 5 employment shares to 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 the 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** I conduct robustness checks for alternative subsample and clustering, spatial correlations across nearby regions and regions with similar initial shares, and LASSO control selection. The results remain robust (Appendix Table B4). I run the analysis excluding regions with large industrial complexes and the capital, Seoul, where manufacturing sectors are concentrated (Choi and Levchenko, 2023) (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).

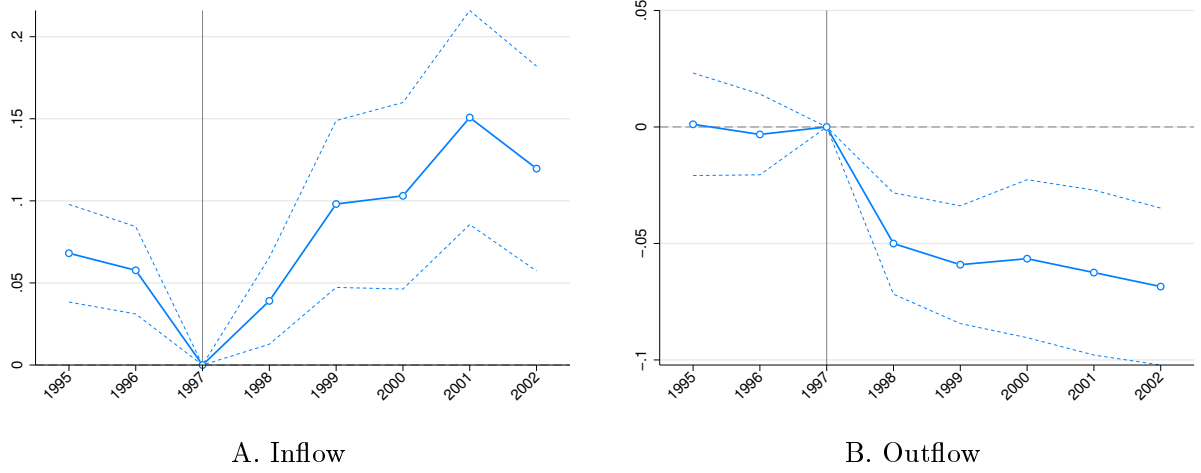
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<sup>8</sup>South Korea is similar in size to Indiana in the US, and regions in my analysis are, on average, 66% the size of US counties, smaller than the average US commuting zone.

<sup>9</sup>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.

<sup>10</sup>Because there are only 15 sectors, I rely on the exogeneity of the initial shares rather than assuming shocks are as-good-as-randomly assigned (Borusyak et al., 2022).

Figure 2. Event Study. Migration Responses to the Crisis



**Note.** Panels A and B illustrate the estimated  $\beta_\tau$  in equation (3.3) for migration inflows and outflows, respectively. All specifications are weighted by the initial population of origin regions 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 dependent variables are log migration shares between origin and destination regions. 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 initial log employment, initial log unemployment, regional balance sheet exposure, log housing price, and the amenity index of destination or origin regions, all of which are interacted with the event-time dummies. See Appendix B.1 for 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:

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

$\text{Empsh}_{m(n)t_0}^{\text{top5}}$  is the initial top 5 employment shares in region  $m$  (or  $n$ ), standardized.  $D_t^\tau$  are the event time dummies.  $\delta_{nm}$  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.<sup>11</sup> I normalize  $\beta_{-1}$  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 aligns

<sup>11</sup>This includes initial log employment, amenity index, log unemployment, regional balance sheet exposure, differences in industrial composition, the regional conflict index, and log distance.

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 coefficients for migration inflows and the estimates would be lower bounds for 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 expansion during the recovery. For 1997-2000, I run

$$\Delta y_n = \beta \text{Bartik}_n + \vartheta \widetilde{\text{Bartik}}_{-n} + \mathbf{X}'_n \boldsymbol{\gamma} + \epsilon_n. \quad (3.4)$$

Because this regression is at the regional level, nearby regions' labor market conditions may affect region  $n$ 's outcomes through the migration linkages, potentially violating the Stable Unit Treatment Values Assumption. To address this issue, I include  $\widetilde{\text{Bartik}}_{-n}$ , as proposed by [Borusyak et al. \(2022\)](#):

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

$\widetilde{\text{Bartik}}_{-n}$  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. 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 examine pretrends and dynamic effects, I run the following event study specification:

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

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, log employment in the top 5 sectors, and log employment in the remaining non-top 5 sectors. I include a similar set of observables used for the migration analysis.<sup>12</sup>  $\text{Bartik}_n$ ,

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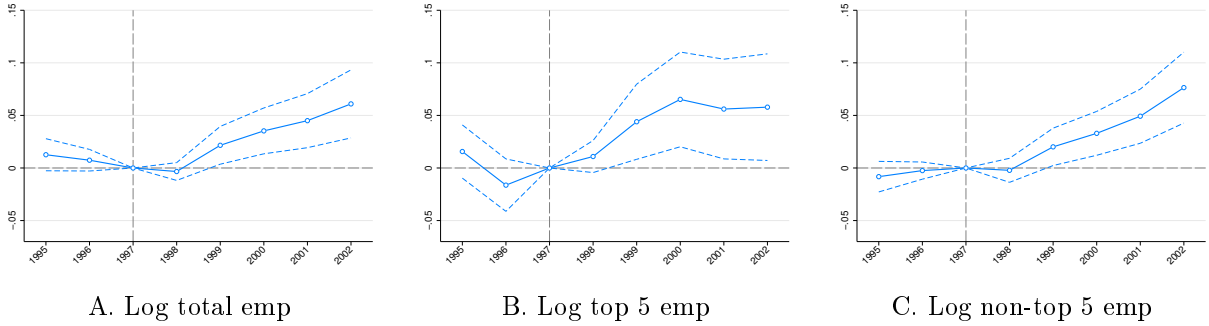
<sup>12</sup>This includes regional balance sheet exposure, changes in log unemployment rates, changes in log housing price, and changes in the amenity index. I did not include the initial log employment as controls because log employment is used as one of the dependent variables.

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

Dep.	$\Delta \log \text{ total emp}$			$\Delta \log \text{ top 5 emp}$			$\Delta \log \text{ non-top 5 emp}$		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Bartik <sub>n</sub>	0.05*** (0.01)	0.04*** (0.01)	0.03** (0.01)	0.07** (0.03)	0.06** (0.03)	0.06* (0.03)	0.04*** (0.01)	0.04*** (0.01)	0.03** (0.01)
$\widetilde{\text{Bartik}}_{-n}$		-0.01* (0.00)	-0.02*** (0.01)		-0.02** (0.01)	-0.04*** (0.01)		-0.01 (0.00)	-0.01* (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, log employment in the top 5 sectors, and log employment in the non-top 5 sectors between 1997-2000, respectively. Bartik<sub>n(m)t<sub>0</sub></sub> 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)), both standardized. Columns 3, 6, and 9 include changes 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 details on the additional controls.

Figure 3. Event Study. Employment Responses to the Crisis



**Note.** The 95% confidence intervals, based on robust standard errors, are reported. This figure illustrates the estimated  $\beta_\tau$  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, log employment in the top 5 sectors, and log employment in the remaining sectors, respectively. The coefficients in 1997 are normalized to zero. All specifications include initial regional balance sheet exposure, log unemployment rate, log housing price, and amenity index, all of which are interacted with the event-time dummies. See Appendix B.1 for details on the additional controls. All specifications include region and year fixed effects.

$\text{Empsh}_{nt_0}^{\text{top5}}$ ,  $\widetilde{\text{Bartik}}_{-n}$ , and  $\widetilde{\text{Empsh}}_{(-n)t_0}^{\text{top5}}$  are standardized. The models are weighted by the initial

employment in 1994.

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  $\widehat{\text{Bartik}}_{-n}$  are negative, implying that favorable shocks in nearby regions reduced employment in region  $n$ . This aligns with the 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 (Moretti, 2010), where an influx of labor into the top 5 sectors boosts labor demand in remaining sectors.<sup>13</sup>

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  $\widehat{\text{Empsh}}_{-n}^{\text{top5}}$  are imprecisely estimated.

I conduct the same robustness checks and shift-share diagnostics similar to those for the migration analysis. The OLS estimates of the long-difference specifications are robust to alternative sample excluding regions with large industrial complexes and the capital city, spatial correlations across nearby regions and regions with similar initial shares, and the LASSO control selection (Appendix Table B8). Also, the event-study estimates are robust to minor violations of the parallel trend assumption (Appendix Figure B10).

## 4 Quantitative Framework

### 4.1 Model

In this section, I develop a dynamic spatial general equilibrium model of migration and trade.

#### 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  $n, m \in \mathcal{N} = \{1, \dots, N\}$ . There are  $J$  sectors, indexed by  $j, k \in \mathcal{J} = \{1, \dots, J\}$ . 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,  $d_{nm}^j \geq 1$  units have to be shipped. I normalize  $d_{nn}^j = 1, \forall n \in \mathcal{N}$ .

<sup>13</sup>For example, a larger labor supply in the top 5 sectors could have decreased overall production costs of all sectors through IO linkages, thereby increasing demand for the remaining sectors and generating local multiplier effects in these sectors. Moretti (2010) estimates the long-term change in non-tradable sector employment due to increased tradable sector employment with an elasticity of 0.3–0.5. Using a similar specification for 1997–2000, I find an elasticity of 0.2–0.5 using OLS or the initial top 5 employment shares as IV.

Each region is populated with representative households. They are forward-looking with perfect foresight and discount the future with 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 make migration decisions 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:

$$q_{njt} = A_{njt} H_{njt}^{\gamma_j^H} \prod_{k=1}^J (M_{njt}^k)^{\gamma_j^k}, \quad \gamma_j^H + \sum_{k=1}^J \gamma_j^k = 1. \quad (4.1)$$

$A_{njt}$  denotes productivity,  $H_{njt}$  labor input, and  $M_{njt}^k$  sector  $k$  material input used by sector  $j$ .  $\gamma_j^H$  and  $\gamma_j^k$  are Cobb-Douglas shares. Under cost minimization, the unit cost of production is

$$c_{njt} = \frac{1}{A_{njt}} \left( \frac{W_{njt}}{\gamma_j^H} \right)^{\gamma_j^H} \prod_{k=1}^J \left( \frac{P_{nkt}}{\gamma_j^k} \right)^{\gamma_j^k}, \quad (4.2)$$

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

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

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

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

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

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



**Trade** Region  $n$ 's sector  $j$  expenditure shares on intermediate goods from region  $m$  and Foreign are given by

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

Region-sector  $nj$ 's export values are

$$EX_{njt} = (d_{nF}^j c_{njt})^{1-\sigma} D_{jt}^F, \quad (4.6)$$

where  $D_{jt}^F$  is Foreign market 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

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

subject to budget constraints:  $P_{nt} C_{nt} = (1 + \iota_t) W_{nt}$ , where  $W_{nt}$  is their wage and  $\iota_t$  is an exogenous tax that rationalizes trade imbalances.<sup>14</sup> Households have Cobb-Douglas preferences over consumption with expenditure shares  $\alpha_j$ . 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 wage:

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

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  $\epsilon_t^\omega = (\epsilon_{n1t}^\omega, \dots, \epsilon_{nJt}^\omega)$ , where  $\epsilon_{njt}^\omega$  represents worker  $\omega$ 's efficiency units of labor

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<sup>14</sup>  $\iota_t$  makes the ratio of per capita expenditure to per capita income vary exogenously over time:  $\iota_t = \frac{\sum_{n=1}^N \sum_{j=1}^J (IM_{njt} - EX_{njt})}{\sum_{n=1}^N W_{nt} h_{nt} L_{nt}}$ , where  $IM_{njt}$  is sector  $j$  import values of region  $n$ . If region-sector trade data are available, I can allow for heterogeneous trade imbalances across regions as in [Caliendo et al. \(2018\)](#). I treat trade deficits as exogenous as is standard in the trade literature ([Dekle et al., 2008](#)). See [Reyes-Heroles \(2016\)](#) and [Dix-Carneiro et al. \(2021\)](#) for incorporating endogenous trade imbalances in the quantitative trade frameworks.

that can be supplied to sector  $j$ . These draws are independently and identically distributed from a multivariate Fréchet distribution across regions and periods:  $F_{nt}(\epsilon_t) = \exp(-\sum_{j=1}^J E_{njt}\epsilon_{njt}^{-\theta})$  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.<sup>15</sup>

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 their workers. They allocate worker  $\omega$  to sector  $j$  only if sector  $j$  offers the highest labor income over other sectors:  $W_{njt}\epsilon_{njt}^\omega \geq W_{nkt}\epsilon_{nkt}^\omega, \forall k \in \mathcal{J}$ . A share of workers allocated to sector  $j$  is

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

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

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

where the regional wage index is

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

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 within-period real wages. When  $\psi = 0$ , the model collapses to the standard Roy-Fréchet framework ([Eaton and Kortum, 2002](#); [Lagakos and Waugh, 2016](#); [Hsieh et al., 2019](#)) where labor is differentiated by sectors with a fixed regional labor supply. Sectoral labor supply is governed by the elasticity  $\theta$ , with higher  $\theta$  implying greater labor mobility across sectors. In the static multi-country and multi-sector setting, [Bonadio et al. \(2023\)](#) models sector 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 net of migration frictions. The dynamic

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<sup>15</sup>In the multi-sector setting, alternative ways of modeling sectoral labor supply shocks are through labor wedges (e.g. [Chari et al., 2007](#); [Huo et al., 2024](#)) or preferences shocks to sector labor supply of the GHH preferences (e.g. [Bonadio et al., 2021](#)). [Bonadio et al. \(2021\)](#) show that formulations of labor supply shocks as changes in efficiency units or preference shocks are observationally equivalent, generating the same changes in real GDP and final consumption.

problem of a household is

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

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

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 \(2021\)](#). Amenity shocks contribute to a more stable population distribution, making it less sensitive to changes in real income.

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

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

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

A share of households who migrate from region  $n$  to  $m$  at the end of period  $t$  is

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

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

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

#### 4.1.4 General Equilibrium

**Market clearing** Goods market clearing requires that

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

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

$$W_{njt} H_{njt} = \gamma_j^H GO_{njt}. \quad (4.15)$$

**Real GDP** Measured real GDP is calculated based on real value-added and measured sectoral PPIs.<sup>16</sup> I use value-added shares to aggregate changes in real GDP at the aggregate and the regional levels following [Caliendo et al. \(2018\)](#). In Appendix C.1, I describe the expressions for the real GDP at the aggregate and regional levels in detail.

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

**Equilibrium** Given state variables  $\{L_{nt}\}_{n=1}^N$  and shocks  $\Psi_t$  and  $\tau_t$ , allocation in each period is determined as in static trade and spatial models. The population evolves according to the optimal migration decisions of households. I formally define the equilibrium as follows:

**Definition 1.** *Given  $\{\Psi_t\}_{t=t_0}^\infty$ ,  $\{\tau_t\}_{t=t_0}^\infty$ , and initial allocations of the state variables  $\{L_{nt_0}\}_{n=1}^N$ , 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 (equation, 4.8); (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,  $\Psi_t^{\text{crisis}} = \{A_{njt}, E_{njt}, D_{jt}^F, P_{jt}^F, 1 + \iota_t\} \subset \Psi_t$ . These shocks capture key features of emerging market economies after crises. Lower  $A_{njt}$  represents large drops in TFP and output (e.g. [Meza and](#)

<sup>16</sup>When constructing PPIs in the model, I mimic statistical agencies' practices (e.g. [Burstein and Cravino, 2015](#); [di Giovanni et al., 2020](#); [Choi et al., 2023](#)).

Quintin, 2007; Pratap and Urrutia, 2012; Queralto, 2020).<sup>17</sup>  $E_{njt}$  relates to various shocks to region-sector labor supply curves during the crisis, such as region-sector specific labor market frictions.<sup>18</sup> Higher  $D_{jt}^F$  and  $P_{jt}^F$  explain large export expansions and import collapses due to depreciations after crises, respectively.<sup>19</sup> Finally,  $1 + \iota_t$  captures rapid decline in trade deficits after crises (e.g. Kehoe and Ruhl, 2009).

**Labor reallocation** In response to the crisis-related shocks, total labor supply in efficiency unit adjusts across region-sectors based on household sectoral labor supply, working hours, and migration decisions, governed by three elasticities,  $\theta$ ,  $\psi$ , and  $1/\nu$ , respectively<sup>20</sup>:

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

Lower migration frictions lead to more flexible reallocation 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 a 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:

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

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

<sup>17</sup>  $A_{njt}$  may capture both negative physical productivity and financial shocks. Appendix C.2.1 illustrates this using a model based on working capital constraints ([Neumeyer and Perri, 2005](#); [Mendoza, 2010](#); [Kim et al., 2015](#)), where balance sheet effects appear as  $A_{njt}$ .

<sup>18</sup> In many classes trade models with labor market frictions such as downward nominal rigidities ([Rodriguez-Clare et al., 2022](#)) or matching frictions ([Carrère et al., 2020](#); [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. Consistent with these models, [Drenik \(2016\)](#) and [Blanco et al. \(2022a\)](#) document the heterogeneous degree of downward nominal rigidities across sectors due to unionization and their importance in understanding distributional consequences and employment dynamics after the 2001 Argentine devaluation episode. Investigating specific sources behind the labor supply shocks is outside the scope of this analysis but remains a fruitful avenue for future research.

<sup>19</sup> [Alessandria et al. \(2010\)](#), [Gopinath and Neiman \(2014\)](#) and [Blaum \(forthcoming\)](#) similarly model depreciation as exogenous shocks to foreign demand and import prices.

<sup>20</sup> Alternatively, workers' migration decisions from one region-sector to another can be modeled similar to [Caliendo et al. \(2019\)](#). This requires data on transitions between region-sectors and frictions of reallocating across different sectors, which can be inferred from observed sector-to-sector transition flows combined with the model. However, due to the unavailability of such data in my setting, workers make two decisions governed by distinct elasticities, whereas in [Caliendo et al. \(2019\)](#), workers' decisions are governed by a single elasticity. Recently, [Rodriguez-Clare et al. \(2022\)](#) introduced separate elasticities for these decisions using a nested structure of household labor supply decisions.

In the baseline economy, there are no changes in migration frictions ( $\hat{m}_{mnt} = 1, \forall t$ ) and only exogenous shocks  $\hat{\Psi}_t$  are fed into the initial allocation. Counterfactual economies with different mobility levels are constructed by feeding both the exogenous shocks and the migration friction shocks. I consider temporary changes in migration friction shocks 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 (e.g. [Lagakos et al., 2023](#)). 1 year before the crisis in 1997, the transitory migration friction 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,  $\hat{m}_{mn,97}^c$  in 1997,  $\hat{m}_{nmt}^c = 1$  for  $t \in \{98, 99, 00, 01\}$ , and  $\hat{m}_{nm,02}^c = 1/\hat{m}_{nm,97}^c$ .

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

- No- and Full-Mobility:  $\hat{m}_{nm,97}^c = C, \forall n, m \in \mathcal{N}$  for some large (no-mobility) and small (full-mobility) numbers, 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:  $\hat{m}_{nm,97}^c = 0.90$  for all pairs, reflecting empirically plausible reductions inferred from observed migration shares ([Head and Ries, 2001](#); [Monte et al., 2018](#)).<sup>21</sup> Between 1997-2007, the median reduction was 10% among inferred frictions.<sup>22</sup>
- Directional 10% reductions: Applied only to migration flows to regions with higher top 5 employment shares than the origin:  $\hat{m}_{nm,97}^c = 0.90$  for pairs that satisfy  $\text{Empsh}_{m,94}^{\text{top5}} > \text{Empsh}_{n,94}^{\text{top5}}$ .

### 4.3 Taking the Model to the Data

This section discusses the calibration procedure for the structural parameters, initial allocation, and exogenous shocks. Table 4 reports a summary of the calibration procedure. Appendix C describes the procedure in detail.

#### 4.3.1 Structural Parameters

**Discount factor** I set the 1-year discount factor  $\beta$  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.<sup>23</sup> I calibrate  $\psi = 0.75$ , the value proposed by [Chetty et al. \(2011\)](#) for use in macro models.

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

<sup>21</sup>Under the symmetry ( $\tau_{mnt} = \tau_{nmt}, \forall n, m \in \mathcal{N}$ ), migration frictions can be inferred from observed migration shares:  $\exp(\tau_{mnt})^{\frac{1}{\nu}} = (\frac{\mu_{mnt}\mu_{mnt}}{\mu_{nnt}\mu_{nmt}})^{-0.5}$ . These inferred frictions are highly correlated with observed proxies such as distance and the regional conflict indices (Appendix Figure C11).

<sup>22</sup>[Monte et al. \(2018\)](#) also found 12% reductions in commuting frictions between 1990 and 2010, similar to the 10% figure. Improvements in transportation infrastructure, such as a 32% increase in paved public roads and a 235% increase

Table 4: Summary of Calibration

Parameters	Value	Description	Target
<i>Elasticities</i>			
$1/\nu$	0.29	Migration elast.	IV estimates, equation (4.16)
$\psi$	0.75	Agg. labor supply elast.	Chetty et al. (2011)
$\theta$	1.5	Sectoral labor supply elast.	Galle et al. (2022)
$\sigma$	5	Trade elast.	Costinot and Rodríguez-Clare (2014)
<i>Geographic frictions</i>			
$\{\xi_j\}$	0.26, 0.4	Trade costs	Monte et al. (2018), Eckert (2019)
<i>Shocks</i>			
$\{\hat{A}_{njt}\}$		Productivity shocks	Gross output, PPI, real GDP growth
$\{\hat{E}_{njt}\}$		Labor productivity shocks	Emp. shares
$\{\hat{D}_{jt}^F\}$		Foreign demand shocks	Sectoral exports
$\{\hat{P}_{jt}^F\}$		Import price shocks	Sectoral imports
$\{1 + \iota_t\}$		Trade deficits	Trade deficits
$\{\hat{b}_{nt}\}$		Amenity shocks	Regional pop.
<i>Preference &amp; Production</i>			
$\beta$	0.96	Discount factor	Literature
$\{\alpha_j\}$		Final consumption shares	IO table
$\{\gamma_j^H, \gamma_j^k\}$		IO coeff.	IO table

**Notes.** This table summarizes the calibration results.

differences between 1997-2000 to recover migration elasticity  $1/\nu$  (Artuc et al., 2010)<sup>24</sup>:

$$\Delta \ln \frac{\mu_{nmt}}{\mu_{nnt}} = \frac{\beta(1+\psi)}{\nu} \Delta \ln \frac{W_{m,t+1}/P_{m,t+1}}{W_{n,t+1}/P_{n,t+1}} + \beta \Delta \ln \frac{\mu_{nm,t+1}}{\mu_{mm,t+1}} + \mathbf{X}'_{nmt_0} \boldsymbol{\gamma} + \tilde{\epsilon}_{nmt}. \quad (4.16)$$

Any time-invariant components of migration frictions or differences in amenities between two regions are differenced out.  $\tilde{\epsilon}_{nmt}$  is the structural error term that is a function of time-varying migration frictions and amenities. Depending on specifications, I control for observables  $\mathbf{X}_{nmt_0}$  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.

in highways, could be factors.

<sup>23</sup>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. (2022), 2.

<sup>24</sup>The regression model captures that current migration flows reflect the future values of expected real income and the 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

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.<sup>25</sup> The Korean statistical agency reports CPI only for the selected regions. Therefore, following [Moretti \(2017\)](#), I impute CPI data for regions with missing 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:

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

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 fixed effects and controls.

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.<sup>26</sup> 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. I can also reject the null hypothesis of weak instrument using the test proposed by [Montiel Olea and Pflueger \(2013\)](#).<sup>27</sup> The estimates are also significant at the 5% level based on the Anderson-Rubin test, which is robust to weak instruments ([Andrews et al., 2019](#)).<sup>28</sup> The results remain robust to excluding pairs 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:  $d_{nm}^j = (\text{Dist}_{nm})^{\xi_j}$ , where  $\text{Dist}_{nm}$  is distance between regions and  $\xi_j$  are parameters that potentially vary 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

<sup>25</sup>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.

<sup>26</sup>[Caliendo et al. \(2021\)](#) report a value of 0.5 at the annual frequency, and [Caliendo et al. \(2019\)](#) report 0.2 at the quarterly frequency.

<sup>27</sup>[Montiel Olea and Pflueger \(2013\)](#) propose a conservative test accommodating heteroskedasticity, serial correlation, and clustering. When there is a single instrument as in the current setup, the KP- $F$  is equivalent to their effective F-statistics. The KP- $F$  values exceed the critical cutoff of 15.1, which corresponds to a test for IV relative bias of no more than 20% at a 5% significance level.

<sup>28</sup>Inference based on the AR statistics is robust to weak instruments in the sense that their probability of incorrectly rejecting the null hypothesis and covering the true parameter value remains well-controlled. Because the IV estimates are non-normally distributed with weak instruments, the AR statistics use test inversion rather than rely on point estimates and standard errors.



Table 5: Migration Elasticity

	Baseline			Dist. $\geq 200\text{km}$	Alt. cluster
	OLS			IV	
	(1)	(2)	(3)	(4)	(5)
<i>Panel A. Second Stage</i>					
$\Delta \ln \frac{W_{m,t+1}/P_{m,t+1}}{W_{n,t+1}/P_{n,t+1}}$	0.14 (0.13)	0.59* (0.34)	0.58* (0.33)	0.61* (0.33)	0.58*** (0.13)
KP- $F$		15.97	15.63	16.08	476.85
AR- $p$		0.05	0.04	0.04	0.00
<i>Panel B. First Stage</i>					
$IV_{nmt}$		0.19*** (0.05)	0.21*** (0.05)	0.22*** (0.05)	0.21*** (0.01)
Controls			✓	✓	✓
N	2914	2914	2914	1852	2914

**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 origin and destination regions. 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.

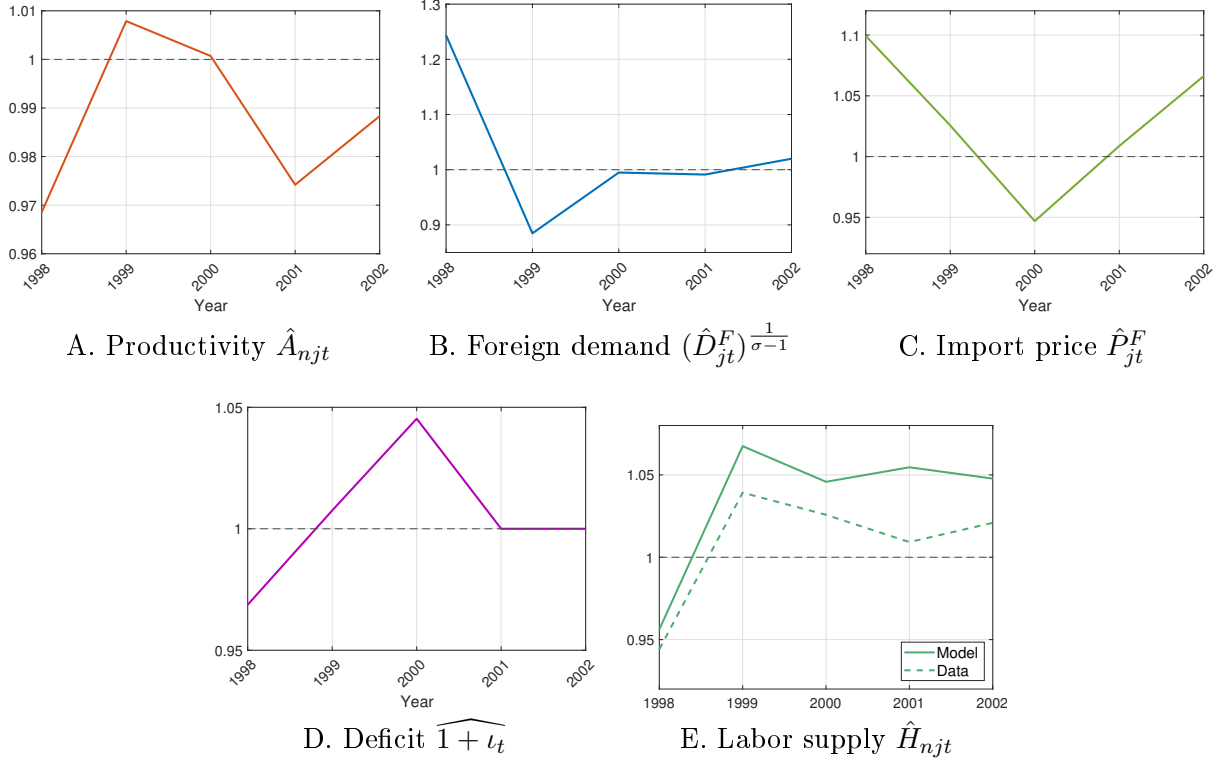
as  $d_{Fn}^j = (\text{PDist}_n)^{\xi_j}$ , where  $\text{PDist}_n$  is region  $n$ 's minimum distance to port. International trade costs that are common across regions are not separately identifiable from  $P_{jt}^F$  and  $D_{jt}^F$ , so  $d_{Fn}^j$  captures the costs relative to those of regions 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  $\{\text{GO}_{njt_0}, \lambda_{njt_0}, \mu_{nm,t_0-1}, L_{nt_0}, \text{EX}_{njt_0}, \pi_{nmt_0}^j, \pi_{Fnt_0}^j\}_{n,m=1,j=1}^{N,J}$  to apply the dynamic hat algebra.  $\{\text{GO}_{njt_0}, \lambda_{njt_0}, L_{nt_0}, \mu_{nm,t_0-1}\}_{n,m=1,j=1}^{N,J}$  is obtained directly from the data. However, I do not have region-sector level information on  $\{\text{EX}_{njt_0}, \pi_{Fnt_0}^j, \pi_{nmt_0}^j\}_{n,m=1,j=1}^{N,J}$ . 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 (Allen et al., 2020). Thus, I can infer these variables by solving the gravity

Figure 4. Recovered Shocks and Labor Supply



**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)).

structure given the available data, detailed in Appendix C.6.1.<sup>29</sup>

#### 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  $\hat{\Psi}_t$  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  $\{\hat{\Psi}_t\}_{t=98}^{02}$ , the shocks evolve as

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

Under the assumed shock process, I recover the shocks between 1997-2002,  $\{\hat{\Psi}_t\}_{t=98}^{02}$ , by fitting the model to the data (e.g. Allen and Arkolakis, 2014; Eaton et al., 2016; Redding, 2016), while taking into account the fact that agents have perfect foresight regarding the sequence of the shocks.

<sup>29</sup>Similarly, Eckert (2019) and Gervais and Jensen (2019) infer trade costs using the gravity structure.

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 distribution between 1997-2002, detailed in Appendix C.6.2.<sup>30</sup>

Although all shocks are jointly identified, some data 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 for each sector in a given 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  $\hat{P}_{jt}^F$  and  $\hat{D}_{jt}^F$ , respectively.<sup>31</sup> 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 distribution identifies  $\hat{b}_{nt}$  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.

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 actual data (Source: KLEMS). The calibration procedure does not target aggregate working hours, so this can be interpreted as a non-targeted moment.

## 5 Quantitative Results

### 5.1 Goodness of Fit: Replicating the Two Empirical Findings

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 data to those from the actual data, reported in Panel A of Table 6. The model captures these estimates well. The long-difference estimates from the model-generated data are within the standard errors of those from the actual data. It 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 ( $\hat{\Psi}_t^{\text{crisis}} = 1$ ) while keeping

<sup>30</sup>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.

<sup>31</sup>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.

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)
<i>Panel A. Actual data &amp; Mode-generated data</i>					
Data	0.09** (0.03)	-0.04*** (0.01)	0.03** (0.01)	0.06* (0.03)	0.03** (0.01)
Model	0.08*** (0.03)	-0.03*** (0.01)	0.03** (0.01)	0.05** (0.02)	0.02 (0.01)
<i>Panel B. Alternative scenarios</i>					
No crisis	0.07* (0.03)	0.02 (0.02)	0.00 (0.01)	0.00 (0.01)	-0.00 (0.02)
Shutting down one shock					
Labor supply shock	0.05 (0.04)	0.06** (0.03)	-0.02 (0.02)	0.02 (0.02)	-0.04* (0.02)
Productivity shock	0.09*** (0.03)	-0.07*** (0.02)	0.04*** (0.01)	0.02 (0.03)	0.04** (0.02)
Trade-related shocks	0.08*** (0.03)	-0.04*** (0.01)	0.03** (0.01)	0.05** (0.02)	0.03** (0.01)
Feeding in one shock					
Labor supply shock	0.02 (0.03)	-0.09** (0.04)	0.06** (0.02)	0.04 (0.03)	0.08*** (0.03)
Productivity shock	-0.02** (0.01)	0.04*** (0.01)	0.01 (0.01)	0.05 (0.03)	-0.01 (0.01)
Trade-related shocks	-0.01** (0.00)	0.00 (0.00)	0.02** (0.01)	0.02* (0.01)	0.01 (0.01)

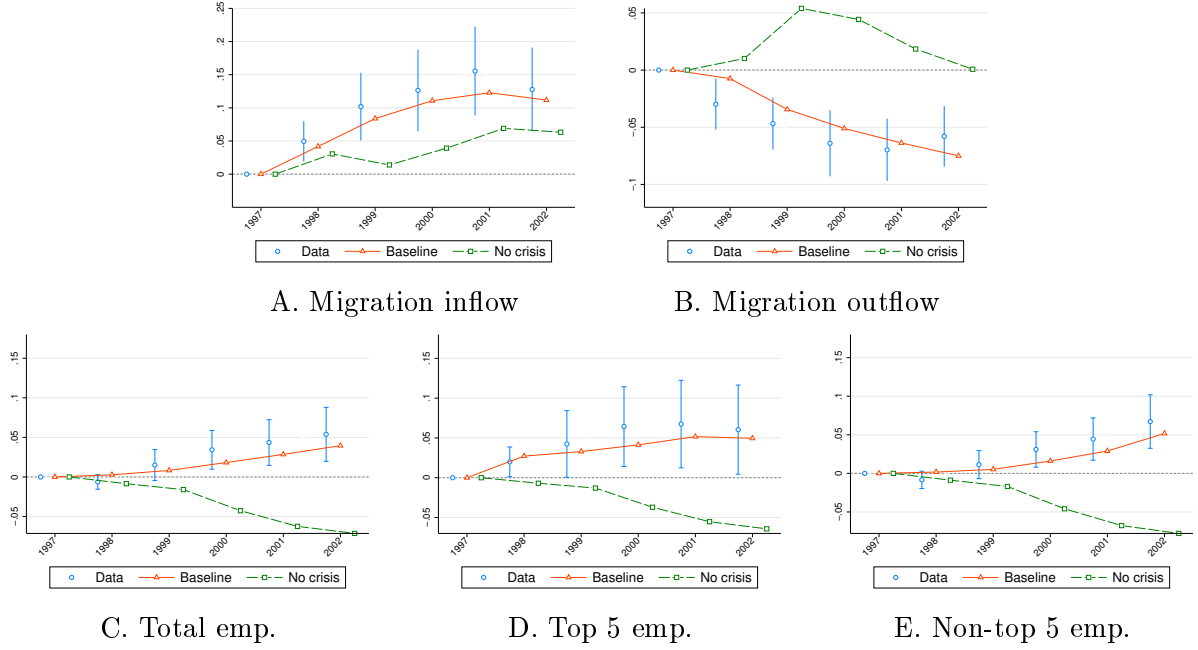
**Notes.** This table presents the estimated coefficients of the Bartik shock of equations (3.1) and (3.4) with the full set of the additional controls (Appendix B.1), respectively. Standard errors are reported in parenthesis. \*:  $p < 0.1$ ; \*\*:  $p < 0.05$ ; \*\*\*:  $p < 0.01$ . Panel A reports the coefficients estimated from the model-generated data actual data. Panels B report the estimates from the model-generated data under alternative sequences of the shocks.

the amenity shock. Panel B and the red-lines in Figure 5) show that 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 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 ( $\hat{D}_{jt}^F$ ,  $\hat{P}_{jt}^F$ , 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

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



**Notes.** This figure compares the estimates of the migration and employment event-study analysis from the actual and the model-generated data. In Panels A and B, dependent variables are migration inflow and outflow, respectively. In Panels C, D, and E, the dependent variables are log total employment, top 5 employment, and 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.

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 (Appendix Figure C12) or feeding in (Appendix Figure C13) individually. These results emphasize the importance of the labor supply side for understanding the dynamic patterns of employment and migration after the crisis. Productivity and trade-related shocks play a more limited role.<sup>32</sup>

## 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

<sup>32</sup>If shocks are correlated, shutting down one shock can affect the others. Productivity and labor supply shocks remain the same when shutting down or feeding in trade-related shocks but trade-related shocks can affect the other two. Gopinath and Neiman (2014) and Blaum (forthcoming) find that higher import price shocks can decrease productivity through firm-level nonhomothetic import behaviors. In such case, trade shocks can have larger impacts by affecting the other shocks.

Table 7: Outflow Migration Rate

	Baseline	No-mobility	Free-mobility	Decrease med.	
				(common)	(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 across regions 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)	(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.

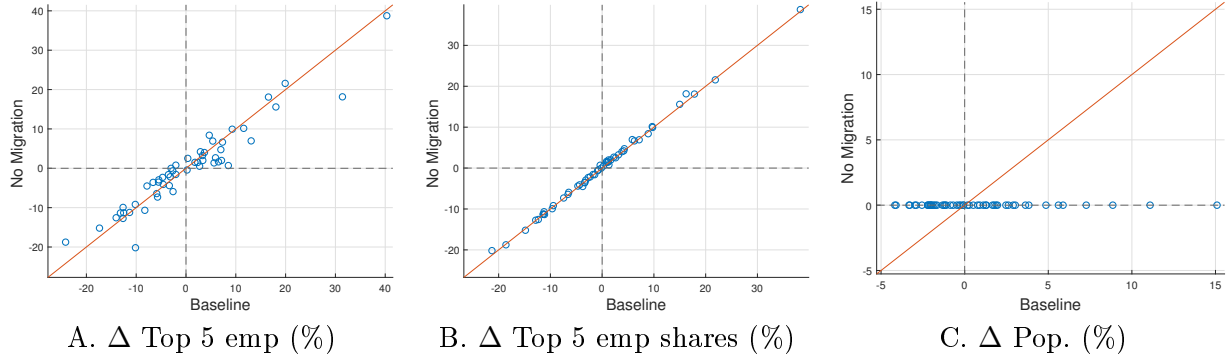
rates ( $\sum_m \mu_{nmt}$ ) between 1998-2001. In the baseline, the average rate was 8.4%, comparable to 11% in Table 1. In the extreme full-mobility counterfactual, the average rate was 90.1%. The common and directional reductions modestly increased the rate by 0.7% and 0.4%, respectively.

**Sectoral reallocation of labor** Because of the imperfect mobility of labor and heterogeneous industrial composition, the desired amounts of sectoral reallocation may not be achieved after the crisis. I examine the relationships between levels of mobility and aggregate employment shares in the top 5 sectors. The top 5 aggregate employment is defined as the sum of the top 5 regional employment.<sup>33</sup>

Table 8 reports the average aggregate shares between 1998-2001, showing that higher mobility is associated with larger top 5 shares. Changes in top 5 employment can result from changes in either employment shares within regions or population adjustment, with most of the changes explained by the latter. Figure 6 compares each region's growth in top 5 employment, top 5 employment shares, and population between 1997-2000 between the baseline mobility and no-mobility counterfactual.

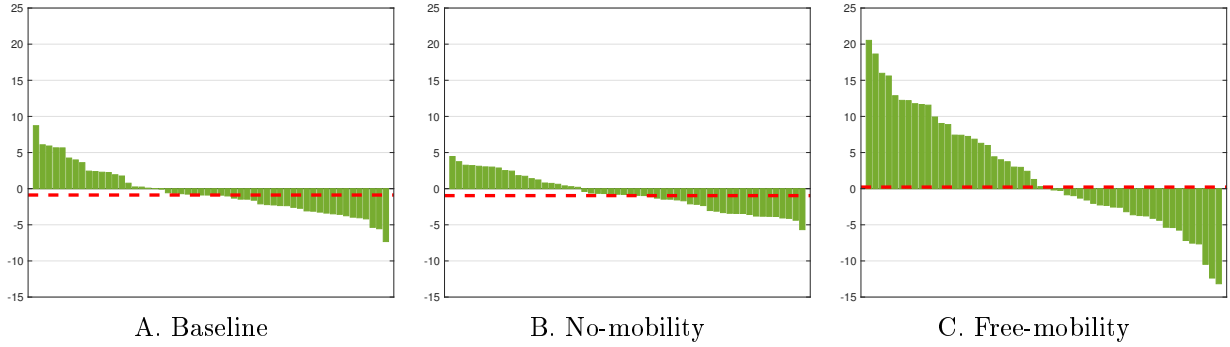
<sup>33</sup>Specifically,  $L_t^{\text{top5}} = \sum_{n=1}^N L_{nt}^{\text{top5}} = \sum_{n=1}^N \sum_{j \in \mathcal{J}^{\text{top5}}} \lambda_{njt} L_{njt}$ , where  $\mathcal{J}^{\text{top5}}$  is a set of the top 5 sectors.

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



**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 the no-mobility counterfactual. The red line represents the 45-degree line.

Figure 7. Migration Mobility and Regional Distribution of Real GDP Growth after Crisis



**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.

Changes in population account for most of variation in top 5 employment, with employment shares within regions explaining only about 1% of the total variation in top 5 employment.

**Real GDP** 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, which is 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, cumulative growth between 1998-2001 exceeded the baseline by 4.36 percentage points. Notably, the disparity between the baseline and full-mobility outcomes surpassed

Table 9: Real GDP Growth

	Baseline	No-mobility	Full-mobility	Decrease med.	
				(common)	(directional)
Years since the crisis	(1)	(2)	(3)	(4)	(5)
<i>Panel A. Crisis</i>					
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( $\prod_{\tau=98}^{01} \hat{Y}_{n\tau}^r$ )	0.13	0.10	0.31	0.13	0.14
$\hat{\beta}^{\text{GDP}}$	0.09*** (0.02)	0.04*** (0.01)	0.15*** (0.04)	0.10*** (0.02)	0.11*** (0.02)
<i>Panel B. No crisis</i>					
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( $\prod_{\tau=98}^{01} \hat{Y}_{n\tau}^r$ )	0.09	0.00	0.28	0.10	0.11
$\hat{\beta}^{\text{GDP}}$	0.04*** (0.02)	0.00 (0.00)	0.07* (0.04)	0.05** (0.02)	0.06*** (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.

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. 9.12%). This suggests that the effectiveness of migration policies to boost aggregate real GDP depends on both the magnitude and direction of 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:  $\ln(\prod_{\tau=98}^{01} \hat{Y}_{n\tau}^r) = \alpha + \beta^{\text{GDP}} \text{Empsh}_{n,94}^{\text{top5}} + \epsilon_n$ , higher mobility had higher estimates for  $\beta^{\text{GDP}}$ , 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 ( $\hat{\Psi}_t^{\text{crisis}} = 1$ ). In Panel B of the no-crisis scenario, full-mobility results in only 2.1 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 gains from mobility larger.<sup>34</sup> Additionally, because the top 5 sectors do not experience larger expansions during normal times, regions specializing in these sectors do not experience larger migration inflows and higher GDP growth, as indicated by the lower magnitude of estimated  $\hat{\beta}^{\text{GDP}}$  under the no-crisis scenario.

**Cost-benefit analysis** While the framework does not explicitly incorporate monetary costs of increasing mobility, the calculated GDP effects provide useful bounds for policymakers to assess whether a policy aimed at improving mobility is 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% and 0.4% 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, the policies would yield greater 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 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 with lower magnitude, because labor plays less important role 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  $\sigma$ ,  $1/\nu$ ,  $\theta$ , and  $\psi$ . Higher  $\sigma$  values increase the magnitude as

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<sup>34</sup>The 200% gains do not come from differences in total migration rates. The differences in the average migration outflows between turbulent and normal times are negligible, less than 0.2 percentage point. The differences are smaller for other mobility levels.

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  $\theta$  values decrease the magnitude by reducing the allocation of workers to the top 5 sectors, as sectoral labor supply becomes more wage-sensitive (Panel C). Similarly, higher  $\psi$  values decrease the magnitude as households reduce working hours more with wage decreases caused by increased labor supply from migration (Panel D).

## 6 Conclusion

This paper studies how internal migration adjusted to the 1998 South Korean crisis 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 flexibly to the crisis and fosters the post-crisis recovery, while making production more geographically concentrated. These findings suggest that tighter spatial linkages across factor markets can improve the flexibility of an economy, and that migration policies can be a viable option to stimulate post-crisis recovery.

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**ONLINE APPENDIX**  
**(NOT FOR PUBLICATION)**

## A Data

I describe the data used for empirical and quantitative analysis.

**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 Statistics Korea, and the Census of Establishment. From the WIOD IO tables, I obtain the national-level sectoral gross output. I allocate this national-level sectoral gross output 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 origin and destination 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,  $\text{SecEX}_{njt_0}$ , 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, the Mining and Manufacturing Survey, the

WIOD Socio–Economic Accounts (WIOD-SEA), and the 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  $\text{Fassets}_{njt}$  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 the balance sheet effects. It is similar to US Compustat and has detailed financial information. However, its advantage over US Compustat is that it includes medium-sized firms that are not publicly traded. I obtain five variables from KIS-VALUE: firm-level employment, foreign currency-denominated debt, foreign currency denominated assets, total assets, and total liabilities.

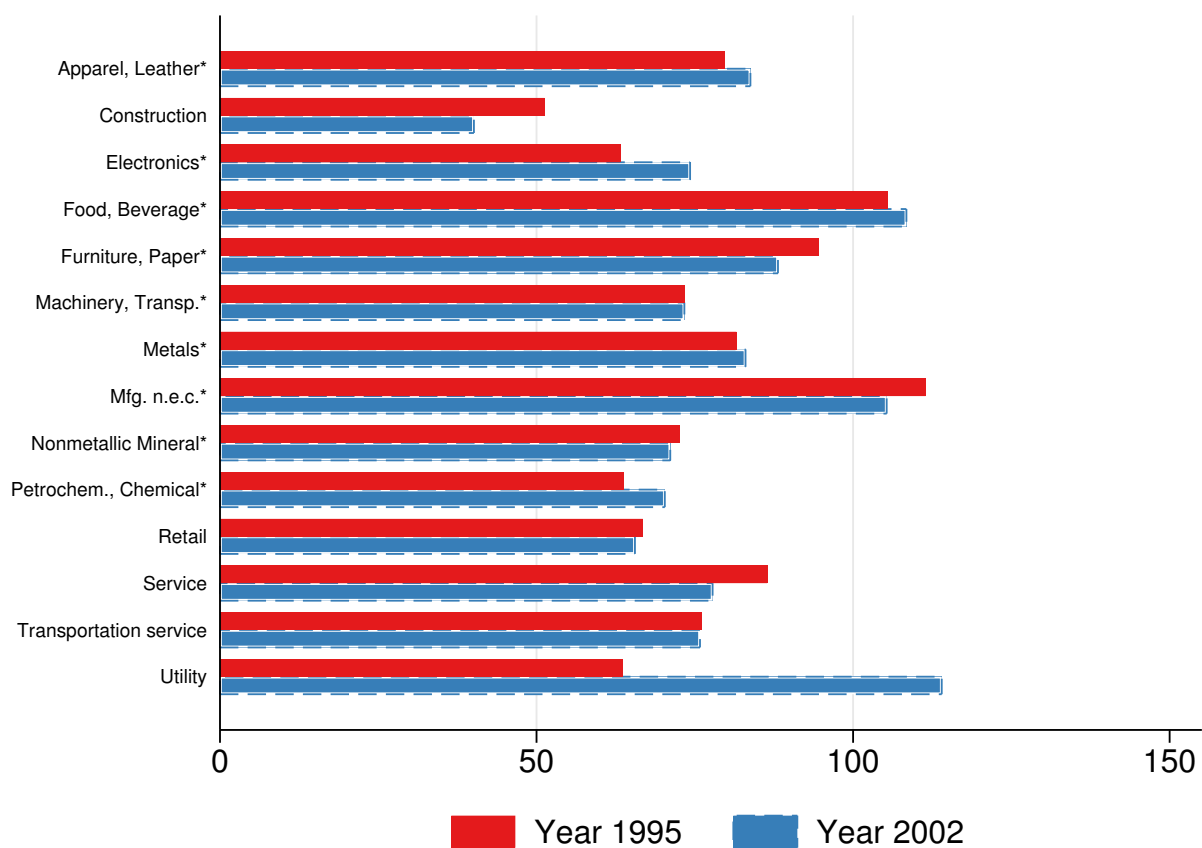
**Data used for constructing the amenity index** Amenity index is computed using Population Census, which is a 2% random sample of total population, Census of Establishment, and the Mining and Manufacturing Survey. From these sources, I calculate the number of retail establishments, the number of establishments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

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

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:

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

Regions with higher employment in sectors with larger  $BS_{j,95}$  are considered more exposed to the balance sheet effect.

**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, 2023). 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:

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

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 the 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:

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

This assumes that differential trends evolve smoothly over time and limits how much their slope can change between consecutive periods. The parameter  $M$  controls the 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:

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

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

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

where  $\perp$  indicates that a variable is residualized by 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. We consider the observables used as additional controls in the analysis, including employment shares of the top 5 sectors most vulnerable to balance sheet exposure based on  $BS_{j,95}$  in equation (B.1) ( $\text{Empsh}_{n,94}^{\text{top5},BS}$ ), initial log unemployment in 1994, initial log housing price in 1994, and initial amenity index 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 ( $\geq 200\text{km}$ )			
	Inflows		Outflow		Inflow		Outflow	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Bartik $_{n(m)t_0}$	-0.01 (0.27)	0.23 (0.24)	-0.03 (0.06)	0.02 (0.08)	0.09** (0.03)	0.07* (0.04)	-0.04** (0.02)	-0.05*** (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	1852	1852	1852	1852

**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 pairs within 200km radius. Bartik $_{n(m)t_0}$  is the standardized Bartik shock (equation (3.2)). Columns 2, 4, 6, and 8 control for the vector of variables used in column 9 of Table 2. 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 origin regions.

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)
<i>Panel A. Migration inflows</i>										
Bartik <sub>m</sub>	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]
<i>Panel B. Migration outflows</i>										
Bartik <sub>n</sub>	-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	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
N	2207	2914	2914	2914	2914	2914	2914	2914	2914	2914

**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  $\Delta \ln \mu_{nm} = \beta \text{Bartik}_m + \mathbf{X}'_m \gamma + \delta_n + \epsilon_{nm}$  and  $\Delta \ln \mu_{nm} = \beta \text{Bartik}_n + \mathbf{X}'_n \gamma + \delta_m + \epsilon_{nm}$ , respectively, where  $\text{Bartik}_n$  is the standardized Bartik shock (equation (3.2)). All specifications are weighted by the initial population of origin regions. 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 standard errors based on spatial correlation principal components (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 a vector of 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 a vector of the additional controls. See Appendix B.1 for 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 the 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 vector of variables used in column 9 of Panel B of Table 2 or columns 3, 6, and 9 of Table 3. 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)
<i>Panel A. Rotemberg weights <math>\hat{\alpha}_j</math></i>				
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
<i>Panel B. Just-identified IV estimators <math>\hat{\beta}_j</math></i>				
$\sum_{j \hat{\alpha}_j>0} \hat{\alpha}_j \hat{\beta}_j$	-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

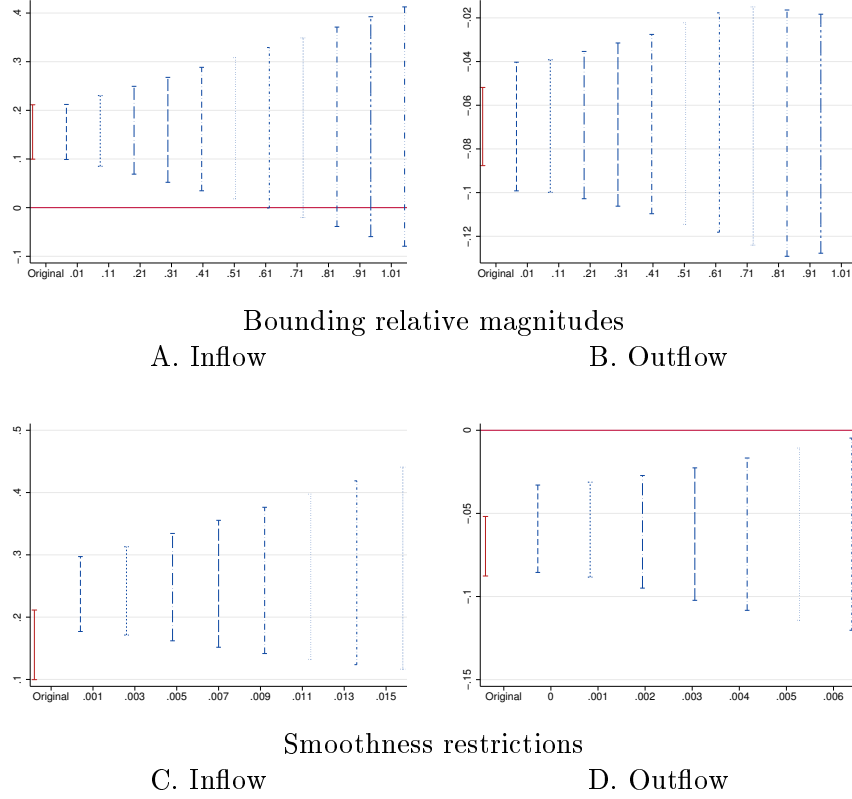
**Note.** This table reports the summary of the Rotemberg weights reported in Table B5.

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 (0.12)				-0.03 (0.13)	-0.24* (0.14)				-0.29* (0.15)
$\ln(\text{Unemp}_{n,95})$		0.18 (0.11)			0.14 (0.14)		0.06 (0.13)			0.11 (0.15)
$\ln(\text{Housing Price}_{n,94})$			-3.66 (4.37)		-1.62 (5.32)			0.49 (4.55)		2.81 (5.33)
$\text{Amenity}_{n,95}$				0.15 (0.11)	0.08 (0.15)				0.10 (0.10)	0.15 (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

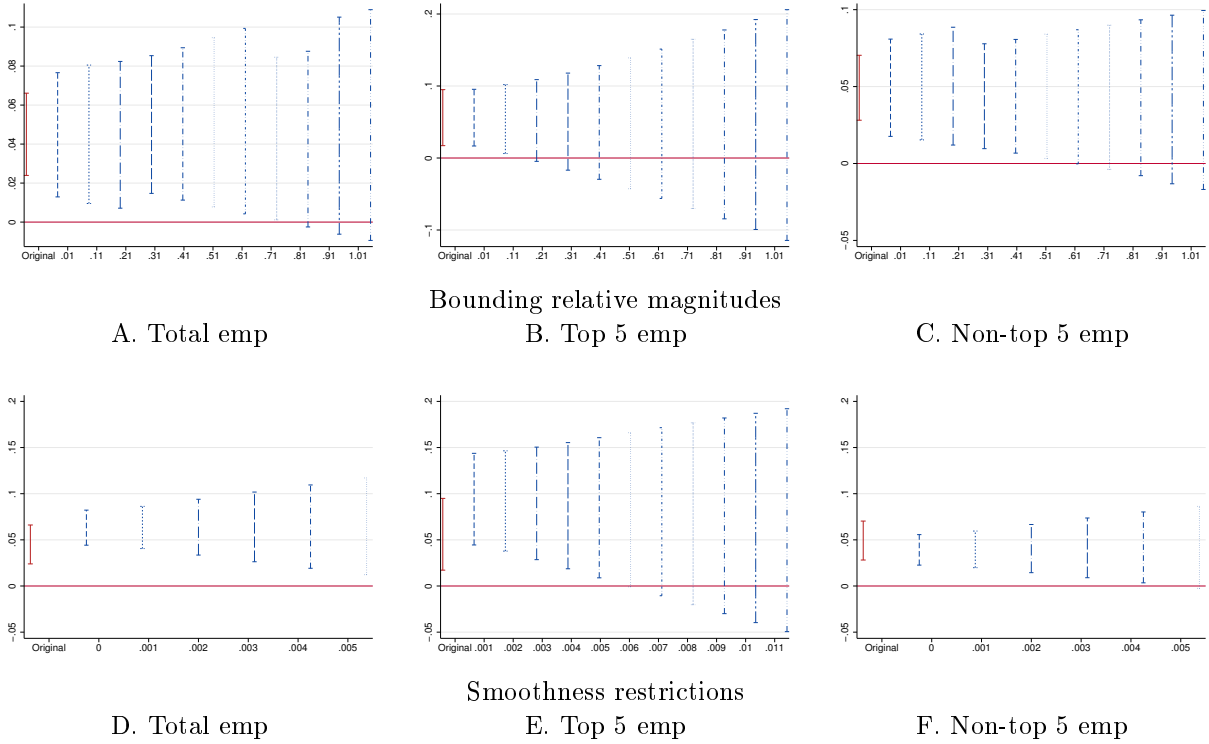
**Note.** Robust standard errors are reported in parenthesis. \*:  $p < 0.1$ ; \*\*:  $p < 0.05$ ; \*\*\*:  $p < 0.01$ . The dependent variables are employment shares of the top 5 sectors in columns 1-5 and the electrical equipment sector in columns 6-10.  $\text{Empsh}_{n,94}^{\text{top5,BS}}$  is an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

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



**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 based on deviations of the pre-event periods (equation (B.3)). In Panels C and D, the restrictions on trends of the post-event periods are based on the 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 are weighted by the initial population of origin regions in 1994. All specifications include the initial log employment in 1994, the initial log unemployment, the initial regional balance sheet exposure, the initial log housing price, and the amenity index in 1995 of destination or origin regions, all of which are interacted with the event-time dummies. See Appendix B.1 for details on the additional controls.

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



**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 based on deviations of the pre-event periods (equation (B.3)). In Panels D, E, and F, the restrictions on trends of the post-event periods are based on the 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, the initial regional balance sheet exposure, the initial log unemployment rate, the initial log housing price, and the initial 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 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)
<i>Panel A. Total employment</i>									
Bartik <sub>n</sub>	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]
<i>Panel B. Top 5 employment</i>									
Bartik <sub>n</sub>	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]
<i>Panel C. Non-top 5 employment</i>									
Bartik <sub>n</sub>	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	✓	✓	✓	✓	✓	✓	✓	✓	✓
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 selection. In Panels A, B, and C, the dependent variables are the changes in the log total employment, the log top 5 employment, and the log non-top 5 employment between 1997-2000, respectively. Column 1 report 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 standard errors based on spatial correlation principal components (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 vector of additional controls included in columns 3, 6, and 9 of Table 3 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 vector of variables used in columns 3, 6, and 9 of Table 3. All specifications are weighted by the initial employment in 1994.



## C Quantitative Framework

### C.1 Real GDP

In this subsection, I describe the expressions for 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:

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

The hat denotes time differences for any variable  $x$ :  $\hat{x}_{t+1} = x_{t+1}/x_t$ .  $\tilde{\omega}_{njt}^{\text{PPI}}$  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:

$$\hat{Y}_t^r = \sum_{n=1}^N \sum_{j=1}^J \omega_{njt}^{\text{agg},r} \widehat{\text{VA}}_{njt}^r, \quad \widehat{\text{VA}}_{njt}^r = \frac{\text{VA}_{njt}}{\widehat{\text{PPI}}_{jt}},$$

$$\omega_{njt}^{\text{agg},r} = \frac{1}{2} \left( \frac{\text{VA}_{nj,t-1}}{\sum_{n=1}^N \sum_{j=1}^J \text{VA}_{nj,t-1}} + \frac{\text{VA}_{njt}}{\sum_{n=1}^N \sum_{j=1}^J \text{VA}_{njt}} \right). \quad (\text{C.2})$$

$\text{VA}_{njt}$  is region-sector  $nj$ 's nominal value-added:  $\text{VA}_{njt} = \gamma_j^H \text{GO}_{njt}$ .  $\widehat{\text{VA}}_{njt}^r$  is region-sector  $nj$ 's real value-added growth deflated by the sectoral PPI. 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:

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

### 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  $\Delta e_{\text{won}/\$}$ . 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  $n_{njt_1} = n_{njt_0} - d_{njt_0} \Delta e_{\text{won}/\$}$ .

Firms are subject to working capital constraints ([Neumeyer and Perri, 2005](#); [Mendoza, 2010](#)).

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  $r_{t_1}(n_{njt_1}, A_{njt_1}) = r_{t_1}^f(1 + \eta(n_{njt_1}, A_{njt_1}))$ . Here,  $r_{t_1}^f$  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 the balance sheet effect. 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  $r_{t_1}$  and  $A_{njt}$  enter the unit cost isomorphically, without additional data moments, they cannot be separately identified.

### C.2.2 Downward Nominal Rigidity and Unemployment

In this section, I show that unemployment rate due to region-sector specific downward nominal rigidity can be related to  $E_{njt}$  by showing that employment rate shows 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:

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

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

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

where  $H_{njt}$  is amount of employed effective labor and  $\tilde{H}_{njt}$  is the 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 not only consider nominal wages  $W_{njt}$  but also employment rate  $e_{njt}$ .

Region  $n$  households' allocate worker  $h$  to sector  $j$  only if sector  $j$  generates the highest labor income adjusted for unemployment rates, over other sector:  $\epsilon_{njt}^h \in \Omega_{njt}$ , where  $\Omega_{njt} = \{\epsilon_t | W_{njt}e_{njt}\epsilon_{njt} \geq W_{nkt}u_{nkt}\epsilon_{nkt}, \forall k \in \mathcal{J}\}$ . To simplify the analysis, I assume that sum of wages generated in region-

sector  $nj$  is equally distributed to all workers allocated to  $nj$ . Shares of workers allocated to sector  $j$  in region  $n$  are expressed as

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

The total labor income of region  $n$ 's household is

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

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 and making the DWNR constraints non-binding every period. Following [Rodriguez-Clare et al. \(2022\)](#), I assume that the nominal GDP of South Korea grows at a constant rate of  $\varphi$ :

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

Labor market clearing conditions satisfy

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

and complementary slackness that combines equation (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 are in the same to those of the baseline model in the main text.

The employment rate  $e_{njt}^\theta$  in equation (C.5) 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  $\delta_{njt}$  can be inferred, implying that  $E_{njt}$  in the model can be associated with  $\delta_{njt}$ . 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 equations (4.16).

**Derivation of equation (4.16)** From equation (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

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

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

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

Note that  $\widehat{1 + \iota_t}$  common across regions are canceled out in the numerator and the denominator.

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:

$$\ln \frac{\mu_{nmt}}{\mu_{nnt}} = \frac{\beta}{\nu} \ln \frac{I_{m,t+1}/P_{m,t+1}}{I_{n,t+1}/P_{n,t+1}} + \beta \ln \frac{\mu_{mn,t+1}}{\mu_{mm,t+1}} + \delta_{nm} + \epsilon_{nmt}. \quad (\text{C.7})$$

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

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

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

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

where  $gCPI_{n,t+1}$  and  $gHP_{n,t+1}$  are growth of CPI and housing price in region  $n$  between  $t$  and  $t+1$ . Using the estimated coefficients  $\hat{\pi}$  and  $\hat{\delta}_t$  and housing prices, I impute the 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:

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

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

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

The average wages of each region 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

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

Sectoral labor supply is given by

$$\hat{H}_{nj,t+1} = (\hat{\lambda}_{nj,t+1})^{\frac{\theta-1}{\theta}} \hat{h}_{n,t+1} \hat{L}_{n,t+1}.$$

Working hours are given by

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

Indirect utility is given by

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

Goods market clearing is

$$\begin{aligned} \text{GO}_{nj,t+1} = \sum_{m=1}^N \pi_{mn,t+1}^j \left[ \sum_{k \in \mathcal{J}} \gamma_k^j \text{GO}_{mk,t+1} \right. \\ \left. + \alpha_j \left( (1 + \iota_{t+1}) \hat{W}_{n,t+1} \hat{h}_{n,t+1} \hat{L}_{n,t+1} W_{nt} h_{nt} L_{nt} \right) \right] + \text{EX}_{nj,t+1}. \end{aligned}$$

Labor market clearing is

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

**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 an anticipated convergence sequence of changes in shocks, the following system of nonlinear equations is satisfied.

Migration shares are expressed as

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

The population evolves according to

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

Value functions are given by

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

**Derivation of equation (C.8) and (C.10)** I derive expressions in equation (C.8) and (C.10). Migration shares can be expressed as

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

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).

After taking equation (4.11) in time differences, I obtain that

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

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  $\{\text{GO}_{njt_0}\}_{n=1,j=1}^{N,J}$
- Region-sector export  $\{\text{EX}_{njt_0}\}_{n=1,j=1}^{N,J}$
- 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  $\theta$
- Frisch labor elasticity  $\psi$
- Elasticity of substitution  $\sigma$
- Cobb-Douglas expenditure shares  $\{\alpha_j\}_{j=1}^J$
- Cobb-Douglas intermediate input shares  $\{\gamma_j^k\}_{j=1,k=1}^{J,J}$

#### Algorithm

- Step 1. Given the path of the shocks  $\{\hat{\Psi}_t\}_{t=98}^T$  and  $\{\hat{m}_{nmt}\}_{n=1,m=1,t=97}^{N,N,T}$ , 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 average wages  $\{\hat{W}_{n,t+1}\}_{n=1}^N$  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  $\{\hat{W}_{nj,t+1}^{(1)}\}_{n=1,j=1}^{N,J}$  that satisfy the labor market clearing condition and check whether  $|\hat{W}_{nj,t+1}^{(1)} - \hat{W}_{nj,t+1}^{(0)}| < \epsilon$  for some tolerance level  $\epsilon$ . If not, use  $\{\hat{W}_{nj,t+1}^{(1)}\}_{n=1,j=1}^{N,J}$  as the new guess and go back to step (a).
- Step 4. For each  $t$ , solve backward for  $\{\hat{u}_{nt}^{(1)}\}_{n=1,t=t_0+1}^{N,T+1}$ :

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

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

#### Data input

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

#### 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:

$$\begin{aligned} \text{GO}_{njt} &= (d_{nF}^j \tilde{c}_{njt})^{1-\sigma} D_{jt}^F + \sum_{m=1}^N \pi_{nmt}^j \left[ \sum_{k=1}^J \gamma_k^j \text{GO}_{mkt} + \alpha_j \left( \sum_{k'=1}^J (1 + \iota_t) \gamma_{k'}^H \text{GO}_{mk't} \right) \right], \\ \text{IM}_{jt} &= \sum_{n=1}^N \left[ \pi_{Fnt}^j \left[ \sum_{k=1}^J \gamma_k^j \text{GO}_{mkt} + \alpha_j \left( \sum_{k'=1}^J (1 + \iota_t) \gamma_{k'}^H \text{GO}_{mk't} \right) \right] \right], \\ \text{EX}_{jt} &= \sum_{n=1}^N \text{EX}_{njt}, \end{aligned}$$



$$\pi_{mnt}^j = \frac{(d_{mn}^j \tilde{c}_{mjt})^{1-\sigma}}{\sum_{m'=1}^N (d_{m'n}^j \tilde{c}_{m'jt})^{1-\sigma} + (d_{nF}^j P_{jt}^F)^{1-\sigma}}, \quad \pi_{Fnt}^j = \frac{(d_{Fn}^j P_{jt}^F)^{1-\sigma}}{\sum_{m'=1}^N (d_{m'n}^j \tilde{c}_{m'jt})^{1-\sigma} + (d_{nF}^j P_{jt}^F)^{1-\sigma}}, \quad (\text{C.11})$$

$$\text{EX}_{njt} = (d_{nF}^j \tilde{c}_{njt})^{1-\sigma} D_{jt}^F. \quad (\text{C.12})$$

Given the data on region-sector gross output,  $\text{GO}_{njt}$ , sectoral exports,  $\text{EX}_{jt}$ , sectoral imports,  $\text{IM}_{jt}$ , and the parametrized trade costs,  $d_{mn}^j$  and  $d_{Fn}^j$ , 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,  $\{\tilde{c}_{njt}, P_{jt}^F, D_{jt}^F\}_{n=1, j=1}^{N, J}$ , and the system of equation is exactly identified up to scale. Without loss of generality, I re-express  $P_{jt}^F$ ,  $D_{jt}^F$ , and  $\tilde{c}_{njt}$  relative to the unit cost of the reference region for each  $j$  and  $t$ :  $\bar{c}_{njt} = \tilde{c}_{njt}/\tilde{c}_{n_0jt}$ ,  $\bar{P}_{jt}^F = P_{jt}^F/\tilde{c}_{n_0jt}$ , and  $\bar{D}_{jt}^F = D_{jt}^F/\tilde{c}_{n_0jt}^{1-\sigma}$ , where  $n_0$  denotes the reference region. Then, I solve for  $\bar{c}_{njt}$ ,  $\bar{P}_{jt}^F$ , and  $\bar{D}_{jt}^F$  for each  $j$  and  $t$  upto normalization.

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

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

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

$$\hat{A}_{njt}^{(0)} = 1 / \left( \prod_{\tau=98}^{02} \hat{A}_{nj\tau}^{(0)} \right)^{\frac{1}{25}}, \quad \forall t \in \{03, \dots, 28\} \text{ and } \hat{A}_{njt}^{(0)} = 1, \quad \forall t \in \{29, \dots, T\}$$

$$\hat{E}_{njt}^{(0)} = 1 / \left( \prod_{\tau=98}^{02} \hat{E}_{nj\tau}^{(0)} \right)^{\frac{1}{25}}, \quad \forall t \in \{03, \dots, 28\} \text{ and } \hat{E}_{njt}^{(0)} = 1, \quad \forall t \in \{29, \dots, T\}$$

$$\hat{b}_{nt}^{(0)} = 1 / \left( \prod_{\tau=98}^{02} \hat{b}_{n\tau}^{(0)} \right)^{\frac{1}{25}}, \quad \forall t \in \{03, \dots, 28\} \text{ and } \hat{b}_{nt}^{(0)} = 1, \quad \forall t \in \{29, \dots, T\}$$

- 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  $n_0$ :  $\{\hat{A}_{njt}^{(0)}/\hat{A}_{n_0jt}^{(0)}\}_{n=1, j=1, t=98}^{N, J, 02}$  based on the following steps.
  1. Using  $\{\bar{c}_{njt}\}_{n=1, j=1, t=97}^{N, J, 02}$  from step 2 in Section C.6.1, compute  $\{\hat{c}_{njt}^{\text{data}}\}_{n=1, j=1, t=98}^{N, J, 02}$ . In the

model, also compute the similar object  $\{\hat{c}_{njt}^{(0)}\}_{n=1,j=1,t=98}^{N,J,02}$ . Note that  $\hat{c}_{n_0jt}^{(0)} = \hat{c}_{n_0jt}^{\text{data}} = 1$  for all sectors in the reference region  $n_0$ .

2. Adjust  $\hat{A}_{njt}^{(0)}/\hat{A}_{n_0jt}^{(0)}$  and iterate steps 2-3 until the gap between  $\{\hat{c}_{njt}^{(0)}\}_{n=1,j=1,t=98}^{N,J,02}$  and  $\{\hat{c}_{njt}^{\text{data}}\}_{n=1,j=1,t=98}^{N,J,02}$  is smaller than the specified threshold  $\epsilon$ .
- Step 5. Update a guess of each region's productivity of the reference sector relative to the reference region  $n_0$ :  $\{\hat{A}_{nj_0t}^{(0)}/\hat{A}_{n_0j_0t}^{(0)}\}_{n=1,j=1,t=98}^{N,J,02}$  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  $\{\widehat{PPI}_{jt}/\widehat{PPI}_{j_0t}\}_{j=1,t=98}^{J,02}$  to the similar object in the data  $\{\widehat{PPI}_{jt}^{\text{data}}/\widehat{PPI}_{j_0t}^{\text{data}}\}_{j=1,t=98}^{J,02}$ .
  2. Adjust the reference region  $n_0$ 's sectoral productivity relative to the reference sector  $j_0$ ,  $\{\hat{A}_{n_0jt}^{(0)}/\hat{A}_{n_0j_0t}^{(0)}\}_{j=1,t=98}^{J,02}$  and iterate previous steps 2-4 until the gap between  $\{\widehat{PPI}_{jt}/\widehat{PPI}_{j_0t}\}_{j=1,t=98}^{J,02}$  of the model and the data is smaller than  $\epsilon$ .
- Step 6. The remaining unpinned productivity component is productivity changes of the reference sector  $j_0$  in the reference region  $n_0$ :  $\{\hat{A}_{n_0j_0t}\}_{t=98}^{02}$ .
  1. Adjust  $\{\hat{A}_{n_0j_0t}^{(0)}\}_{t=98}^{02}$  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  $\epsilon$ .
- Step 7. Update labor supply shocks  $\{E_{njt}^{(0)}\}_{n=1,j=1,t=98}^{N,J,02}$ .
  1. Compare  $\{\hat{\lambda}_{njt}^{(0)}\}_{n=1,j=1,t=98}^{N,J,02}$  computed from the model to  $\{\hat{\lambda}_{njt}^{\text{data}}\}_{n=1,j=1,t=98}^{N,J,02}$  obtained from the data.
  2. Adjust  $\{\hat{E}_{njt}^{(0)}\}_{n=1,j=1,t=98}^{N,J,02}$  and iterate previous steps 2-6 until  $|\hat{\lambda}_{njt}^{(0)} - \hat{\lambda}_{njt}^{\text{data}}| < \epsilon$ .
- Step 8. Update  $\{\hat{b}_{nt}^{(0)}\}_{n=1,t=98}^{N,02}$ . Because  $\hat{b}_{nt}$  is identified up to normalization, I normalize  $\hat{b}_{n_0t} = 1$  for the reference region  $n_0$ .
  1. Compare  $\{\hat{L}_{nt}^{(0)}\}_{n=1,t=98}^{N,02}$  computed from the model to  $\{\hat{L}_{nt}^{\text{data}}\}_{n=1,t=98}^{N,02}$  from the data.
  2. Adjust  $\{\hat{b}_{nt}^{(1)}\}_{n=1,t=98}^{N,02}$  and iterate previous steps 2-8 until  $|\hat{L}_{nt}^{(0)} - \hat{L}_{nt}^{\text{data}}| < \epsilon$ .
- 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:

$$\nu_{nt}^k = \sum_{s=t_0}^{\infty} \beta^{t+s} \frac{(C_{n,t+s}^k)^{1-\frac{1}{\phi}}}{1-\frac{1}{\phi}}, \quad (\text{C.13})$$

subject to the budget constraint  $r_{nt}K_{nt} = P_{nt}(C_{nt}^k + K_{n,t+1} - (1-\delta)K_{nt})$ , where  $r_{nt}$  is the rental rate of capital.  $r_{nt}K_{nt}$  is the total income from the existing capital stock,  $P_{nt}C_{nt}^k$  is the total value

of their consumption, and  $P_{nt}(K_{n,t+1} - (1 - \delta)K_{nt})$  is the total value of their investment.

Capital is an input to production and production function is given as

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

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:

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

where  $R_{nt} = 1 - \delta + r_{nt}/P_{nt}$  is the gross return on capital and  $\zeta_{nt}$  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 the fraction 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

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

The equilibrium with capital accumulation is defined as follows.

**Definition 2.** Given the parameters of the model,  $\{\Psi_t\}_{t=t_0}^\infty$ ,  $\{\tau_t\}_{t=t_0}^\infty$ , 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, expected lifetime utilities, rental rate of capital, and capital stock  $\{L_{nt}, \lambda_{njt}, W_{njt}, V_{nt}, r_{nt}, K_{n,t+1}\}_{n=1, j=1, t=t_0}^{N, J, \infty}$  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 allocate their workers across different sectors (equation, 4.8); (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 the path 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 path converges at  $T + 1$ , so set  $\hat{u}_{n,T+1}^{(0)} = 1$ .
- Step 2. Based on the guessed consumption rates and the 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 path of migration shares  $\{\mu_{nmt}\}_{t=t_0+1}^{T+1}$ :

$$\mu_{nm,t+1} = \frac{\mu_{nmt}(\hat{u}_{m,t+2})^{\frac{\beta}{\nu}}(\hat{m}_{nm,t+1})^{\frac{1}{\nu}}}{\sum_{m' \in \mathcal{N}} \mu_{nm't}(\hat{u}_{m',t+2})^{\frac{\beta}{\nu}}(\hat{m}_{nm',t+1})^{\frac{1}{\nu}}}.$$

Using the computed migration shares  $\{\mu_{nmt}\}_{t=1}^{T+1}$ , compute population for periods  $t \geq t_0 + 1$ :

$$L_{n,t+1} = \sum_{m \in \mathcal{N}} \mu_{mnt} L_{mt}.$$

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  $R_{n,t+1}$ <sup>35</sup>:

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

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  $t + 2$ :

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

---

<sup>35</sup>Because  $R_{n,t+1} \equiv (1 - \delta) + \frac{r_{n,t+1}}{\hat{P}_{n,t+1}}$ ,  $\frac{R_{n,t+1} - (1 - \delta)}{R_{nt} - (1 - \delta)} = \frac{\hat{r}_{n,t+1}}{\hat{P}_{n,t+1}}$  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  $R_{n,t+1} = (1 - \delta) + \frac{\hat{W}_{nj,t+1} \hat{H}_{nj,t+1}}{\hat{P}_{n,t+1} \hat{K}_{nj,t+1}} (R_{nt} - (1 - \delta))$ .

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

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

- 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.

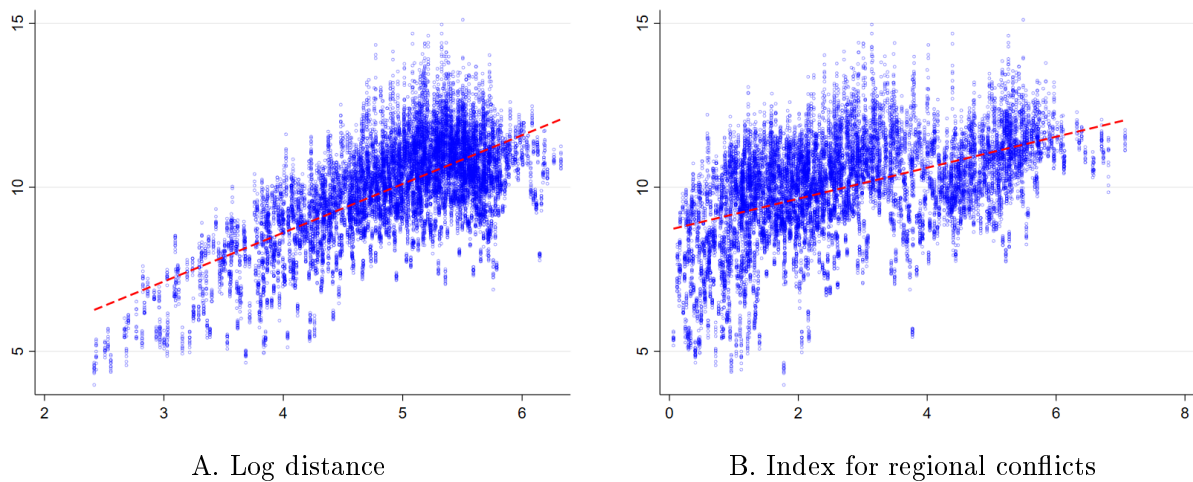
- Step 8. Take  $\{(1-\omega)\hat{u}_{nt}^{(0)} + \omega\hat{u}_{nt}^{(1)}\}_{t=t_0+1}^{T+1}$  and  $\{(1-\omega)\zeta_{nt}^{(0)} + \omega\zeta_{nt}^{(1)}\}_{t=t_0+1}^{T+1}$  for some weight  $\omega \in (0, 1]$ , and return to Step 2.
- Step 9. Continue until both  $\{\hat{u}_{nt}^{(1)}\}$  and  $\{\zeta_{nt}^{(1)}\}$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

**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.

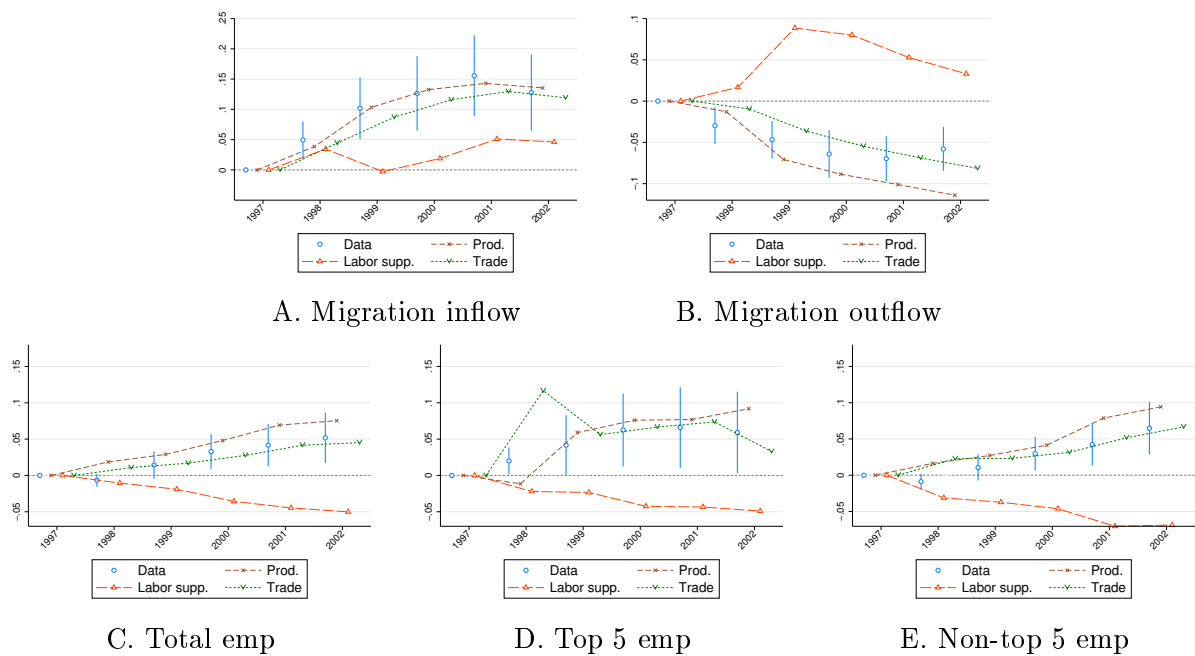
## C.8 Additional Figures and Tables

Figure C11. Correlates of the Inferred Migration Frictions



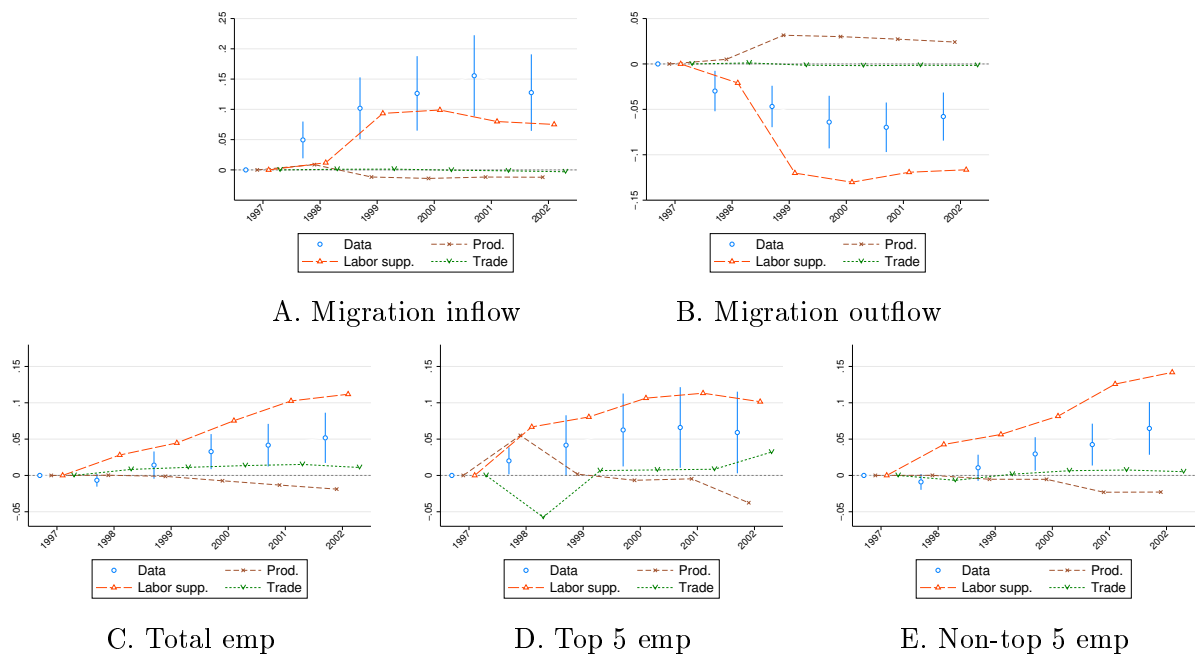
**Notes.** Panels A and B are the scatter plots between the inferred migration frictions and log distance and between such frictions and the index for regional conflicts. The red dashed lines are the corresponding linear fits.

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



**Notes.** The figure 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, dependent variables are log migration inflow, log migration outflow, log total employment, log top 5 employment, and log 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



**Notes.** The figure the estimates of the migration and employment event-study coefficients when feed in only a set of specified shocks at a time. In Panels A, B, C, D, and E, dependent variables are log migration inflow, log migration outflow, log total employment, log top 5 employment, and log 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 C9: Robustness. Aggregate Real GDP Growth after the Crisis

	$\Delta$ No-mobility -Baseline	$\Delta$ Free-mobility -Baseline	$\Delta$ Decrease med. (common)	-Baseline (directional)
	(1)	(2)	(3)	(4)
	$\Delta$ Cumulative growth ( $\prod_{\tau=98}^{02} Y_{\tau}^r$ ) (p.p.)			
Main Calibration	-0.32	4.35	0.02	0.15
	<i>Panel A</i>			
Permanent changes in $\hat{m}_{nmt}$	-0.32	4.24	0.03	0.12
	<i>Panel B</i>			
No amenity shocks	-0.39	3.98	0.0	0.11
	<i>Panel C</i>			
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. See Appendix C.3 for more details on real GDP.

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

	$\Delta$ No-mobility - Baseline	$\Delta$ Free-mobility - Baseline	$\Delta$ Decrease med. - Baseline (common)	$\Delta$ Decrease med. - Baseline (directional)
	(1)	(2)	(3)	(4)
	$\Delta$ Cumulative growth ( $\prod_{\tau=98}^{02} Y_{\tau}^r$ ) (p.p.)			
Main Calibration	-0.32	4.35	0.02	0.15
	<i>Panel A. Elasticity of substitution</i>			
Low, $\sigma = 2$	-0.29	3.27	0.02	0.14
High, $\sigma = 6$	-0.34	5.16	0.03	0.17
	<i>Panel B. Migration elasticity <math>1/\nu</math></i>			
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
	<i>Panel C. Sectoral labor supply elasticity <math>\theta</math></i>			
Low, $\theta = 1.05$	-0.33	4.68	0.03	0.16
High, $\theta = 2$	-0.33	4.10	-0.00	0.14
	<i>Panel D. Aggregate labor supply elasticity</i>			
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. See Appendix C.3 for more details on real GDP.