ONLINE APPENDIX TO:
REGIONAL EFFECTS OF
EXCHANGE RATE FLUCTUATIONS

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1 Data

The data sources for all variables are as follows (if not noted otherwise, data covers 1999q1 - 2018q4).

- Exports: Origin of Movements series compiled by the Foreign Trade Division of the U.S. census (trade in goods only).


- U.S. dollar exchange rates: IMF International Financial Statistics

- CPI: IMF International Financial Statistics

- GDP: IMF International Financial Statistics

- Unemployment rate: BLS 'Local Area Unemployment Statistics'; seasonally adjusted

- Employment (total private and manufacturing only): BLS 'State and Area Employment, Hours, and Earnings'; data refers to 'all employees' and is seasonally adjusted.

- Hours worked (total private and manufacturing only) (2007q1 - 2018q4): BLS 'State and Area Employment, Hours, and Earnings'; BLS reports (non-seasonally adjusted) average weekly hours per employee, which we multiply by the number of employees to obtain total hours worked.

- State-level real GDP (2005q1 - 2018q4): BEA Regional Accounts

- State migration: Annual data provided by the IRS and Census. See HPT for further details. Annual data temporarily disaggregated using the Chow-Lin method with unemployment rates as quarterly indicators.

2 Chow-Lin Method

Our net migration data is only available at the annual frequency, whereas our statistical analysis is performed at a quarterly frequency. We therefore apply the Chow and Lin (1971)

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\[\text{We use seasonally adjusted data for real GDP. For some countries, we seasonally adjust the data ourselves using the X-13 toolbox provided by the U.S. Census and implemented in Matlab.}\]
method to temporarily disaggregate the net migration dataset using quarterly unemployment rate data as high-frequency indicators.

The main goal of this method is to create quarterly net migration data that is consistent with the annual, observed, net migration data. In practice, we impose the following relationship between a state $i$'s quarterly net migration rate, $nm_{i,t}^q$, (with $t$ denoting a year and $q$ denoting a quarter) and a state's quarterly unemployment rate, $ur_{i,t}^q$:

$$nm_i = ur_i \beta_i + \epsilon_i,$$

where the innovation $\epsilon_i$ follows an AR(1) process. Here, $nm_i$ and $ur_i$ are time-series vectors of length $4T \times 1$, with $T$ being the number of years, e.g.

$$nm_i = \begin{bmatrix} nm_1^i & nm_2^i & \cdots & nm_4^i \end{bmatrix}'$$

The Chow and Lin (1971) method derives the best linear unbiased estimator of $\beta_i$ under the temporal constraint that makes $nm_{i,t}$ quantitatively consistent with its annual counterpart $NM_{i,t}$:

$$NM_{i,t} = \sum_{q=1}^{4} nm_{i,t}^q, \quad \forall t.$$  

We apply this method for each state separately, that is we estimate a different $\beta_i$ for each state $i$. We refer the reader to the original paper (Chow and Lin, 1971) for more details on how the estimator of $\beta_i$ is constructed.

3 Robustness Results

In the main body of the text, we run the following regressions for each time horizon $h \geq 0$:

$$x_{n,t+h} - x_{n,t-1} = \alpha_t^h + \alpha_n^h + \beta_s^h \Delta \ln s_{n,t}^* + \beta_y^h \Delta \ln y_{n,t}^* + \left( \sum_{k=1,2} \gamma_k^h \Delta x_{n,t-k} \right) + \epsilon_{n,t+h}, \quad (3.1)$$

where $x_{n,t}$ is a measure of economic performance (e.g. the unemployment rate or log GDP) in state $n$ at time $t$. The main coefficient of interest is $\beta_s^h$ that describes the response of the unemployment rate at horizon $h$ to a log change in the real effective export exchange rate, $\Delta \ln s_{n,t}^*$, calculated according to (??). Our regression includes both state fixed effects and
time fixed effects. We also control for demand changes in export markets through $\Delta y^*_n,t$, the log change in real GDP for state $n$’s trade-weighted export market relative to the log change in U.S. real GDP and is similarly constructed to (??).

In Figure 1, we show that our results are robust to including four lags of the right-hand-side variable (instead of two), i.e. $k = 1, 2, 3, 4$. For the results presented in Figure 2, we add two lagged changes in log GDP to the right hand side of (3.1) as additional controls. Again, this modification leaves our empirical results virtually unchanged.

4 Extrapolating Trade Exposure Backwards

Data on state-level trade are missing before 1999 (exports) / 2008 (imports). We can extrapolate these series backwards using (i) the fraction of state $n$’s trade with country $j$ ($tr^j_n$), (ii) trade data at the national level broken down by partner country ($trade^j_t$) and (iii) state-level GDP ($gdp_{n,t}$):

$$trade^j_{n,t} = \frac{tr^j_n \times gdp_{n,t}}{\sum_n tr^j_n \times gdp_{n,t}} \times trade^j_t. \quad (4.1)$$

The formula distributes national trade with country $j$ across states using weights. These weights reflect states’ share in trade with $j$ and assume that states’ trade scale one-for-one with their GDP. We calculate $tr^j_n$ over the first two years of our sample, e.g. for exports

$$ex^j_n = \frac{\sum_{t=99,00} exports^j_{n,t}}{\sum_{t=99,06} gdp^j_{n,t}}.$$ 

For imports, we average over 2008 - '09.

Adjusting the trade preference weights in the model. In our model, we can use these estimates to adjust the $\omega^j_i$ trade preference weights. These trade preference weights are derived from $(N+1) \times (N+1)$ trade matrix, where the last column describes states’ imports from outside the United States, and the last row describes states’ exports to foreign countries. The final element of the matrix, $\omega^{N+1}_{N+1}$, is empty. This trade matrix is published by the Freight Analysis Framework (FAF) that sources its data from the Commodity Flow Survey, among others. It is available for the years 1997, 2002, 2007 and 2012 up to 2016. In our calibration, we average the data over 2002, 2007, 2012 and 2016.
Our goal is to estimate such a matrix for years prior to 1997, e.g. $t = 1989$. We proceed in three steps:

1. **We estimate a state’s final demand (or: absorption, $abs$)**

   $$ abs_{n,t} = \frac{abs_n}{gdp_n} gdp_{n,t}, $$

   where variables without a time subscripts refer to the year 1997.

2. **We adjust our trade data for $t$ by taking into account that our estimated data for 1997 differs from the data reported for 1997 in the FAF**

   $$ trade_{n,t} = \frac{trade_{n,1997}}{trade_{est_{n,1997}}} trade_{est_{n,t}}, $$

   where $trade$ refers to the FAF data, and $trade_{est}$ is a state’s estimated trade calculated as the sum across partners derived from (4.1).

3. **We estimate interstate trade as follows:**

   $$ imports^j_{n,t} = \frac{abs_{n,t} - imports_{n,t}^{j}}{abs_n - imports_n^{j}}. $$

   In words, this procedure scales interstate trade (including a state’s trade with itself) up or down according to the change in foreign trade: If the share of a state’s final demand satisfied via imports raises by 2 percentage points, this procedure scales down all other shares (i.e. final demand satisfied by domestic production and other states production) by a common factor to ensure that shares sum up to 1.

**References**

Figure 1: **Empirical Impulse Response to a Real Effective Exchange Rate Depreciation: Robustness 1**

Notes: Figure displays the local projection of (a) the real effective exchange rate, (b) nominal exports and imports (expressed in percent of state’s GDP), (c) the unemployment rate, (d) state GDP, (e) hours worked and (f) cumulative net immigration to a 1% depreciation of the real effective exchange rate based on regression (3.1). We include four lags of the variable of interest as controls (as opposed to two lags in the benchmark). The definition of the (export) effective exchange rate covers the U.S. market, including the state itself. State GDP is real, total GDP at the state level. Bands are 90 percent confidence intervals.
Figure 2: Empirical Impulse Response to a Real Effective Exchange Rate Depreciation: Robustness 2

Notes: Figure displays the local projection of (a) the real effective exchange rate, (b) nominal exports and imports (expressed in percent of state’s GDP), (c) the unemployment rate, (d) state GDP, (e) hours worked and (f) cumulative net immigration to a 1% depreciation of the real effective exchange rate based on regression (3.1). Compared to the benchmark reported in the main body of the text, we include two lags of state-GDP growth rates as controls in all regressions. The definition of the (export) effective exchange rate covers the U.S. market, including the state itself. State GDP is real, total GDP at the state level. Bands are 90 percent confidence intervals.