Trade and the Spatial Distribution of Unemployment

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February 4, 2026

Abstract

I develop a static model of involuntary unemployment in multiple geographic locations. The model merges a quantitative general equilibrium model of the spatial economy and the efficiency-wage model (Shapiro and Stiglitz, 1984). In this model, nominal wages respond to foreign exogenous shocks less flexibly than in models with frictionless labor markets. I quantify the model for 27 countries and the 50 US states and compute a counterfactual of a 3 % increase in China's productivity. The model predicts that real wages increase in all the U.S. states, unemployment increases in 49 states, and the overall U.S. welfare increases. These counterfactual predictions differ from those generated by a full-employment model and a model with voluntarily chosen unemployment.

Keywords: unemployment, international trade, efficiency wages, spatial equilibrium
JEL classification: F16, J64, R13

1 Introduction

Over the past decade, a growing number of empirical research has explored labor market consequences of international trade. A notable result is that unemployment rates increased more in U.S. commuting zones which were more exposed to import competition with China (Autor et al., 2013, 2016). This cross-regional finding calls for investigation on aggregate effects of international trade on unemployment, and ultimately, welfare.

While quantitative general equilibrium models have advanced in capturing complex interaction across countries and locations, however, the bulk of these models presume full employment (Eaton and Kortum, 2002; Anderson and van Wincoop, 2003) or voluntary nonemployment (Caliendo et al., 2019). This paper aims to bridge the empirical literature on the effect of international trade on involuntary unemployment and the literature on quantitative trade and spatial models.

I develop a static general equilibrium model of involuntary unemployment across many locations. The model merges a quantitative trade and spatial model and the efficiency-wage model

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of Shapiro and Stiglitz (1984). A key driver to generate involuntary unemployment is, namely, efficiency wages. Workers can shirk. If workers shirk, firms cannot produce. Firms imperfectly monitor shirking. If firms catch shirking, they fire shirkers. To prevent workers from shirking, firms set a higher wage than the market-clearing wage, so that the cost of being caught and unemployed is higher. This non-market-clearing wage causes involuntary unemployment.

I quantify the model for 27 countries and the 50 U.S. states as of 2012. To illustrate differences between my model and existing models, I also quantify a model with full employment and a model in which workers can voluntarily choose unemployment (but cannot be involuntarily unemployed). I consider a counterfactual 3% increase in China's productivity.

Counterfactual predictions of my efficiency-wage model are clearly different from those of the other two models. Since the full-employment model and the voluntary-unemployment model make similar predictions, here I discuss counterfactual predictions of the efficiency-wage model and the full-employment model.

In both models, the counterfactual increase in China's productivity induces increases in real wages. But the size is order-of-magnitude different across the models. In the efficiency wage model, the employment-weighted average U.S. real wage increases by 0.07%, whereas in the full employment model, only 0.008%.[1] This difference is driven by efficiency wages. As the large foreign country's productivity increases, the price index decreases in the U.S. However, in the efficiency-wage model, the nominal wage does not flexibly decrease as much as in the full-employment model. Therefore, overall, the real wage, which is the nominal wage divided by the price index, increases more in the efficiency-wage model.

However, the higher nominal wage in the efficiency-wage model comes at a cost in two margins: profits and involuntary unemployment. The increase in China's productivity causes decreases in real profits in both models. The size of the decrease is slightly larger in the efficiency-wage model than in the full-employment model. The real profits decrease by 0.05% in the efficiency-wage model; 0.04% in the full-employment model. The increase in China's productivity makes U.S. firms relatively less competitive in the global market. Therefore, the real profits decline in both models. But, since the nominal wage stays high in the efficiency-wage model, the real profits decline even more in the efficiency-wage model than in the full-employment model.

Yet the other margin in the efficiency-wage model is involuntary unemployment. The increase in China's productivity induces increases in unemployment in 49 U.S. states out of 50. Indeed, the number of unemployed workers increase by 1.3 % nationwide. Of course, this margin of unemployment does not operate in the full employment model by construction.

Overall, a 3% increase in China's productivity increases the U.S. welfare by 0.09% in the efficiency-wage model but decreases the U.S. welfare by 0.01% in the full-employment model. Since the decline in real profits and the increase in unemployment act to decrease welfare, the reason for these opposite welfare predictions across the two models is real wages. Although stickiness of nominal wages is the source of involuntary unemployment in the efficiency-wage

[1] Units of geography are states in the U.S., so I compute changes in employment-weighted average real wages for nationwide effects. See Section 4 for precise definitions. State-level outcomes are also discussed in Section 4.

model, it keeps nominal wages high despite lower import prices, leading to the elevated real wages. Putting differently, in the full-employment model, there is no margin in (un)employment, so the China shock directly damages nominal wages and partially offsets the positive effects on real wages. But, in the efficiency-wage model, unemployment acts as a buffer against the China shock and keeps real wages high.

A 3% increase in China's productivity causes welfare increases in 10 countries (including the U.S.) and welfare decreases in 18 countries in the efficiency-wage model. The same counterfactual change induces welfare increases in 7 countries and welfare decreases in 21 countries (including the U.S.) in the efficiency-wage model. More countries are better off in the efficiency-wage model than in the full employment model because, again, real wages increase more in the efficiency-wage model.

The counterfactual results highlight heterogeneous effects of China's productivity improvement across U.S. states. West Coast states experience larger real-wage gains and smaller increases in unemployment than states in the Great Plains and parts of the Midwest.

This spatial pattern is largely explained by cross-state differences in exposure to trade with China. States with higher import intensity from China benefit more from reductions in consumer prices and intermediate input costs following China's productivity growth. To demonstrate this mechanism, I incorporate state-level hypothetical import and export exposure to China into the exact-hat-algebra framework and recompute the counterfactual effects of a 3 % increase in China's productivity.

I also demonstrate that initial levels of unemployment rates play a minor role in shaping changes in unemployment in response to China's productivity improvement in my quantitative model.

This paper contributes to the literature on quantitative general equilibrium models of international trade (Eaton and Kortum, 2002; Anderson and van Wincoop, 2003) and the spatial economy (Allen and Arkolakis, 2014; Redding, 2016). In this literature, Caliendo et al. (2019) study the effect of the China shock on labor markets across the US states with a dynamic Ricardian model with migration. In their paper, individuals choose a sector to work in and a US state to live in, and sector 0 is labeled as nonemployment. That is, individuals voluntarily choose nonemployment. In contrast, individuals are involuntarily unemployed in my main framework.

This paper is not the first to apply the efficiency-wage model to international trade. Davis and Harrigan (2011) and Wang and Zhao (2015) combine the efficiency-wage model and the Melitz (2003) model. As far as I know, however, the efficiency-wage model has not been merged to a many-country quantitative trade model.

This paper belongs to the literature on many-region models that comprise involuntary unemployment. Bilal (2023) develops a dynamic spatial model with job search. Goods are freely traded in his model, while trade costs are incurred between different locations in this paper. Eaton et al. (2013) assume fixed wages and endogenize employment in the Eaton-Kortum model. Rodriguez-Clare et al. (2024) introduce downward nominal wage rigidity into the model of Caliendo et al. (2019). These two papers *exogenously* assume wage rigidity, while my model has a microfoundation for involuntary unemployment. Finally, Carrere et al. (2020) merges a multi-sector version of the Eaton-Kortum model (Caliendo and Parro, 2015) with a static version of the search and matching model of Mortensen and Pissarides (1994). In contrast, my model builds on the efficiency-wage model and allows labor mobility across U.S. states.

The remainder of this paper is organized as follows. Section 2 develops the model. Section 3 describes data and parameterization. Section 4 shows counterfactual results. Section 5 concludes. Appendices include details and proofs of my main efficiency-wage model, details of the full-employment model and the voluntary-unemployment model, and some additional figures and tables.

2 Model

Let N_{US} be the set of the 50 US states. Let N_{NUS} be the set of countries but the US, where the subscript NUS stands for "not the US." The economy consists of $N = N_{US} \cup N_{NUS}$. A location $j \in N$ is either a US state or a non-US country.

An individual in the US endogenously chooses a US state to live in. The mass of the labor force L_j in $j \in N_{US}$ is endogenously determined in equilibrium. Let L_{US} be the total labor force in the US. Then $\sum_{j \in N_{US}} L_j = L_{US}$. An individual in non-US country j cannot emigrate from her country. Thus the mass of the labor force L_j in $j \in N_{NUS}$ is exogenously given.

A timing assumption follows. An individual in the US chooses her state to live in. Then, she may or may not be employed in her destination. She cannot emigrate from her state to another, even if she is unemployed.

This section proceeds as follows. Subsection 2.1 describes consumers' utility maximization and firms' profit maximization given the labor forces in the US states. Subsection 2.2 states location choices of individuals in the US, which pins down the distribution of the labor forces over the US states. Subsection 2.4 defines an equilibrium.

2.1 Consumer and Firm Behavior

Utility maximization

If individual i lives in location $j \in N$, her utility is

$$U_{i,j} = \frac{1}{\tilde{\eta}_i} C_{i,j} A_j \nu_{i,j}, \tag{1}$$

where $C_{i,j}$ is the composite good consumed by individual i who lives in location j, $\tilde{\eta}_i$ represents the disutility from making an effort, A_j is the amenities of location j that is common to anyone, and $\nu_{i,j}$ is individual i's idiosyncratic amenity shock for location j.[2] A unit continuum of firms produce

[2] The form of the utility function (1) follows Davis and Harrigan (2011), who assume that the disutility from making an effort is multiplicative. It is slightly different from the original specification in Shapiro and Stiglitz (1984), who assume that the disutilty from making an effort is subtractive.

differentiated varieties in any location $k \in N$. The composite good $C_{i,j}$ for individual i in location j is defined by

$$C_{i,j} = \left(\sum_{k \in N} \int_0^1 C_{i,k,j}(\omega)^{\frac{\sigma-1}{\sigma}} d\omega \right)^{\frac{\sigma}{\sigma-1}},$$

where $C_{i,k,j}(\omega)$ is individual i's consumption of variety ω shipped from location k to her location j, and σ is the parameter of CES. The associated price index P_j is

$$P_j = \left[\sum_{k \in N} \int_0^1 (p_k(\omega) t_{k,j})^{1-\sigma} d\omega \right]^{\frac{1}{1-\sigma}}, \tag{2}$$

where $p_k(\omega)$ is the f.o.b. price of variety ω produced in location k, and $t_{k,j}$ is the iceberg trade costs of any variety shipped from location k to location j. Note that the price of variety ω from location k that consumers in location j face is $p_k(\omega) t_{k,j}$.

Each individual is either employed or unemployed. If individual i is employed, she chooses to make an effort or to shirk. If she makes an effort, her utility is divided by $\eta > 1$, but if she shirks, she does not incur this disutility. That is, using the notation $\tilde{\eta}_i$ in equation (1),

$$\tilde{\eta}_i = \begin{cases} \eta > 1 & \text{if } i \text{ makes an effort,} \\ 1 & \text{if } i \text{ shirks.} \end{cases}$$

If individual i is unemployed, she does not incur the disutility from making an effort, $\tilde{\eta}_i = 1$.

If an individual in location j is employed (and is not caught shirking), she receives the nominal wage w_j. If she is unemployed, she receives the nominal home production $b_j P_j$, where b_j is the real home production in location j.

Besides the wage or home production, no matter whether she is employed or not, an individual receives a share of profits. Let π_j be total profits of firms in location j. If she lives in non-US country $j \in N_{NUS}$, she receives the share of profits $\frac{\pi_j}{L_j}$. If she lives in US state $j \in N_{US}$, she receives the share of profits $\frac{\pi_{US}}{L_{US}}$, where $\pi_{US} = \sum_{k \in N_{US}} \pi_k$ is total profits in the US. In other words, anyone in non-US country $j \in N_{NUS}$ owns the same share of ownership of firms in her country j. Anyone in the US owns the same share of ownership of firms in the US, no matter which state she lives in.

The nominal income for individual i in location j, $\tilde{w}_{i,j}$, is

$$\tilde{w}_{i,j} = \begin{cases} w_j + \frac{\pi_j}{L_j} & \text{if } i \text{ is employed in } j \in N_{NUS}, \\ b_j P_j + \frac{\pi_j}{L_j} & \text{if } i \text{ is unemployed in } j \in N_{NUS}, \\ w_j + \frac{\pi_{US}}{L_{US}} & \text{if } i \text{ is employed in } j \in N_{US}, \\ b_j P_j + \frac{\pi_{US}}{L_{US}} & \text{if } i \text{ is unemployed in } j \in N_{US}. \end{cases} \tag{3}$$

Then, the budget constraint for individual i in location $j \in N$ is

$$\sum_{k \in N} \int_0^1 p_k(\omega) t_{k,j} C_{i,k,j}(\omega) d\omega \le \tilde{w}_{i,j}. \tag{4}$$

To solve utility maximization, first I consider consumers' choice of consumption bundle subject to the budget constraint. Then I turn to consumers' choice on whether to make an effort or not.

Individual i's demand for variety ω shipped from location k to her location j, $C_{i,k,j}(\omega)$, is

$$C_{i,k,j}(\omega) = \left(\frac{p_k(\omega) t_{k,j}}{P_j} \right)^{-\sigma} \left(\frac{\tilde{w}_{i,j}}{P_j} \right). \tag{5}$$

Since the budget constraint (4) is binding, the CES demand aggregator for individual i in location j, $C_{i,j}$, satisfies

$$P_j C_{i,j} = \tilde{w}_{i,j}. \tag{6}$$

Any firm in location j can catch shirking with probability $q_j \in (0,1)$. If a shirker is caught, she is fired and ends up unemployed. Her shirking is not caught with probability $1 - q_j$, then the shirker receives the same wage w_j as those who make an effort. The parameter q_j represents imperfect contract in the labor market in location j.

Substituting $C_{i,j} = \frac{\tilde{w}_{i,j}}{P_j}$ into utility (1), I obtain the following expressions for indirect utilities. If individual i in location j is unemployed, her indirect utility is

$$\begin{aligned} \left(b_j + \frac{\pi_j}{L_j P_j} \right) A_j \nu_{i,j} \ \text{ for } j \in N_{NUS}, \\ \left(b_j + \frac{\pi_{US}}{L_{US} P_j} \right) A_j \nu_{i,j} \ \text{ for } j \in N_{US}. \end{aligned} \tag{7}$$

If individual i in location j is employed and makes an effort, her indirect utility is

$$\begin{aligned} \frac{1}{\eta} \left(\frac{w_j}{P_j} + \frac{\pi_j}{L_j P_j} \right) A_j \nu_{i,j} \ \text{ for } j \in N_{NUS}, \\ \frac{1}{\eta} \left(\frac{w_j}{P_j} + \frac{\pi_{US}}{L_{US} P_j} \right) A_j \nu_{i,j} \ \text{for } j \in N_{US}. \end{aligned} \tag{8}$$

If individual i in location j is employed and shirks, her expected indirect utility is

$$\begin{aligned} (1 - q_j) \cdot \left(\frac{w_j}{P_j} + \frac{\pi_j}{L_j P_j} \right) A_j \nu_{i,j} + q_j \cdot \left(b_j + \frac{\pi_j}{L_j P_j} \right) A_j \nu_{i,j} \ \text{ for } j \in N_{NUS}, \\ (1 - q_j) \cdot \left(\frac{w_j}{P_j} + \frac{\pi_{US}}{L_{US} P_j} \right) A_j \nu_{i,j} + q_j \cdot \left(b_j + \frac{\pi_{US}}{L_{US} P_j} \right) A_j \nu_{i,j} \ \text{ for } j \in N_{US}. \end{aligned} \tag{9}$$

Individual i makes an effort if the indirect utility of making an effort (8) is greater than the expected indirect utility of shirking (9). She shirks if (8) is less than (9). She is indifferent between making an effort and shirking if (8) is equal to (9).

Production function

Suppose that firm $\omega \in [0,1]$ in location j hires the measure $l_j(\omega)$ of workers. If the measure $l'_j(\omega) \in [0, l_j(\omega)]$ of employees actually make an effort, the production of firm ω in location j, $y_j(\omega)$, is

$$y_j(\omega) = z_j \left(\frac{l'_j(\omega)}{1-\beta}\right)^{\beta} \left(\frac{m_j(\omega)}{\beta}\right)^{1-\beta}. \tag{10}$$

where z_j is the productivity that is common to all firms in location j, and $m_j(\omega)$ is the input of intermediate goods and β is the parameter that represents the labor share in total costs. The input bundle of intermediate goods is the same as consumers' composite good. Shirkers do not contribute to production.

No shirking condition

Assume that any individual receives a wage offer with probability e_j, once she chooses her location j.[3] The probabilities $\{e_j\}_{j\in N}$ are endogenously determined in general equilibrium.[4] A wage offer arrives from at most one firm to an individual. Firms have the full bargaining power, and a wage offer is a take-it-or-leave-it offer. If an individual receives a wage offer and accepts it, she will be hired by a firm. If an individual receives a wage offer and rejects it, she will be unemployed. If an individual does not receive a wage offer, she will be unemployed.

In equilibrium, firms offer the wage equalizing the indirect utility of making an effort (8) and the expected indirect utility of shirking (9), that is,

$$\begin{aligned}
\frac{1}{\eta}\left(\frac{w_j}{P_j} + \frac{\pi_j}{L_j P_j}\right) A_j \nu_{i,j} &= (1-q_j)\cdot\left(\frac{w_j}{P_j} + \frac{\pi_j}{L_j P_j}\right) A_j \nu_{i,j} + q_j \cdot \left(b_j + \frac{\pi_j}{L_j P_j}\right) A_j \nu_{i,j} \quad \text{for } j \in N_{NUS}, \\
\frac{1}{\eta}\left(\frac{w_j}{P_j} + \frac{\pi_{US}}{L_{US} P_j}\right) A_j \nu_{i,j} &= (1-q_j)\cdot\left(\frac{w_j}{P_j} + \frac{\pi_{US}}{L_{US} P_j}\right) A_j \nu_{i,j} + q_j \cdot \left(b_j + \frac{\pi_{US}}{L_{US} P_j}\right) A_j \nu_{i,j} \quad \text{for } j \in N_{US}.
\end{aligned} \tag{11}$$

Solving this for w_j, I obtain

$$w_j = \begin{cases} \frac{1}{1-\eta(1-q_j)}\left(\eta q_j b_j P_j + (\eta-1)\frac{\pi_j}{L_j}\right) & \text{for } j \in N_{NUS}, \\ \frac{1}{1-\eta(1-q_j)}\left(\eta q_j b_j P_j + (\eta-1)\frac{\pi_{US}}{L_{US}}\right) & \text{for } j \in N_{US}. \end{cases} \tag{12}$$

See Appendix A.1 for a proof. The idiosyncratic amenity shock $\nu_{i,j}$ does not appear in the wage (12). That is, the nominal wage (12) equalizes the indirect utility of making en effort and the expected indirect utility of shirking not only for individual i, but also for anyone in location j.

[3] Location choices do not take place in non-US countries $j \in N_{NUS}$. Thus the timing assumption about location choices and wage offers does not apply in $j \in N_{NUS}$.

[4] I will show that e_j is the employment rate in location j, because no one rejects a wage offer in equilibrium.

Since $\eta > 1$ and $0 < q_j < 1$ for any $j \in N$, the no-shirking wage (12) is strictly greater than the nominal home production,

$$w_j > b_j P_j.$$[5]

Therefore anyone accepts a wage offer if she receives it. As a result, e_j represents the employment rate in location j as well as the probability that an individual in location j receives a wage offer.

Once an individual accepts the wage offer (12) and gets hired, she does not shirk.[6] For this reason, I refer the condition (11) and wage (12) as the no-shirking condition and no-shirking wage, respectively.

Given the no-shirking wage (12) and the zero measure of shirkers, the unit cost for any firm in location j is

$$\frac{w_j^{\beta} P_j^{1-\beta}}{z_j}. \tag{13}$$

Suppose temporarily that the price index P_j and profits π_j are held fixed in the no-shirking wage (12) for $j \in N_{NUS}$, although they are actually general equilibrium objects. Then, two properties hold. First, the no-shirking wage w_j is increasing in η, the disutility from making an effort. If the disutility from making an effort is larger, firms have to compensate employees with a higher wage. Second, the no-shirking wage w_j is decreasing in q_j, the probability that firms catch shirking. If shirkers are more likely to be caught, workers voluntarily make an effort with a lower wage. Then firms no longer have to offer a high wage. Now I return to the general equilibrium model where $\{P_j\}_{j\in N}$ and $\{\pi_j\}_{j\in N}$ are endogenous.

Aggregate nominal income and expenditure

The aggregate nominal income in location j, I_j, is given by

$$I_j = \begin{cases} e_j L_j \left(w_j + \frac{\pi_j}{L_j}\right) + (1-e_j) L_j \left(b_j P_j + \frac{\pi_j}{L_j}\right) & \text{for } j \in N_{NUS}, \\ e_j L_j \left(w_j + \frac{\pi_{US}}{L_{US}}\right) + (1-e_j) L_j \left(b_j P_j + \frac{\pi_{US}}{L_{US}}\right) & \text{for } j \in N_{US}. \end{cases} \tag{14}$$

This is the sum of the aggregate nominal incomes of the employed (the first term) and the unemployed (the second term).

The aggregate expenditure in location $j \in N$ is

$$X_j = I_j + \frac{1-\beta}{\beta} w_j e_j L_j, \tag{15}$$

where the first term on the right-hand side is the final absorption and the second term on the right-hand side is the purchase of intermediate goods.

[5]A sufficient condition for this is $1 - 2\eta + \eta q_j < 0$. $\eta > 1$ and $0 < q_j < 1$ satisfy this.

[6]See Appendix A.1 for a proof.

Profit maximization - Constant markup

Let $C_{j,k}(\omega)$ be the aggregate demand for variety ω shipped from location j to location k. Since preferences are homothetic, by replacing an individual's nominal income $I_{i,j}$ in equation (5) with the aggregate nominal expenditure X_k, I obtain the aggregate demand for variety ω shipped from location j to location k, $C_{j,k}(\omega)$, by

$$C_{j,k}(\omega) = \left(\frac{p_j(\omega)t_{j,k}}{P_k}\right)^{-\sigma}\left(\frac{X_k}{P_k}\right). \tag{16}$$

From the viewpoint of monopolistic firm ω in location j, equation (16) means that how much the demand in location k would be if firm ω sets the f.o.b. price $p_j(\omega)$.

Note that firm ω in location k needs to ship $t_{k,j}C_{k,j}(\omega)$ to meet the demand $C_{k,j}(\omega)$ in location j, because of the iceberg trade costs $t_{k,j}$. Thus to meet the demands from all destinations, firm ω in location j must produce the amount

$$y_j(\omega) = \sum_{k\in N} t_{j,k}C_{j,k}(\omega). \tag{17}$$

Given the no-shirking wage (12), firm $\omega \in [0,1]$ in location j maximizes its profits $\pi_j(\omega)$ given by

$$\begin{aligned}
\pi_j(\omega) &= p_j(\omega)y_j(\omega) - \frac{w_j^{\beta}P_j^{1-\beta}}{z_j}y_j(\omega) \\
&= \left(p_j(\omega) - \frac{w_j^{\beta}P_j^{1-\beta}}{z_j}\right)\left(\sum_{k\in N} t_{j,k}C_{j,k}(\omega)\right) \\
&= \left(p_j(\omega) - \frac{w_j^{\beta}P_j^{1-\beta}}{z_j}\right)\left[\sum_{k\in N} t_{j,k}\left(\frac{p_j(\omega)t_{j,k}}{P_k}\right)^{-\sigma}\frac{X_k}{P_k}\right],
\end{aligned} \tag{18}$$

where the first line means revenue minus cost, the second line follows from the goods market clearing (17), and the third line follows from the CES aggregate demand (16). Taking the first order condition with respect to $p_j(\omega)$, the optimal price for any monopolistic firm ω in location j is

$$p_j(\omega) = \frac{\sigma}{\sigma-1}\frac{w_j^{\beta}P_j^{1-\beta}}{z_j}, \tag{19}$$

which is the constant markup $\frac{\sigma}{\sigma-1}$ multiplied by the unit cost. Substituting the optimal price (19) into the price index (2) (with modifying subscripts), the price index in location j is

$$P_j = \left[\sum_{k\in N}\left(\frac{\sigma}{\sigma-1}\frac{w_k^{\beta}P_k^{1-\beta}}{z_k}t_{k,j}\right)^{1-\sigma}\right]^{\frac{1}{1-\sigma}}. \tag{20}$$

Since the measure one of firms exist in each location, substituting the optimal price (19) into the profits (18), I have the aggregate profits in location j as

$$\pi_j = \frac{1}{\sigma} \sum_{k \in N} \left(\frac{\sigma}{\sigma - 1} \frac{w_j^{\beta} P_j^{1-\beta} t_{j,k}}{z_j P_k} \right)^{1-\sigma} X_k \tag{21}$$

for any $j \in N$.

Aggregate labor cost is equalized to aggregate labor income:

$$\beta \frac{\sigma - 1}{\sigma} \sum_{k \in N} \left(\frac{\sigma}{\sigma - 1} \frac{w_j^{\beta} P_j^{1-\beta} t_{j,k}}{z_j P_k} \right)^{1-\sigma} X_k = w_j e_j L_j, \tag{22}$$

for any $j \in N$. In standard trade models, the labor market clears in value terms, yielding a condition analogous to (22) but with $w_j L_j$ on the right-hand side, since unemployment is ruled out ($e_j = 1$). Because the employment rate e_j may be strictly less than one in my model, I refer to (22) as the labor-market non-clearing condition.

This formulation has one limitation: the implied employment rate e_j is not guaranteed to lie in the unit interval. As a consequence, for a 10% increase in China's productivity, the model predicts a decline in China's unemployment rate of 10.4 percentage points, even though the baseline unemployment rate in 2012 is only 4.1%. In Section 4, I consider a relatively small shock, a 3% increase in China's productivity, as a counterfactual exercise. Under this counterfactual, all employment rates lie between 0 and 1.

2.2 Location Choices

I have stated all equilibrium conditions for non-U.S. countries $j \in N_{NUS}$. I turn to location choices of individuals in the U.S.

Individual i in the U.S. chooses a U.S. state to live in after she draws her idiosyncratic amenity shock $\nu_{i,j}$ for $j \in N_{US}$. Individual i chooses her location to maximize her expected indirect utility. That is, individual i solves

$$\max\{V_{i,j} : j \in N_{US}\}, \tag{23}$$

where $V_{i,j}$ is her expected indirect utility of living in U.S. state j,

$$\begin{aligned} V_{i,j} &= e_j \cdot \frac{1}{\eta} \left(\frac{w_j}{P_j} + \frac{\pi_{US}}{L_{US} P_j} \right) A_j \nu_{i,j} + (1 - e_j) \cdot \left(b_j + \frac{\pi_{US}}{L_{US} P_j} \right) A_j \nu_{i,j}, \\ &= \Phi_j \nu_{i,j}, \end{aligned} \tag{24}$$

and Φ_j is the baseline expected indirect utility of living in U.S. state j which is common to anyone in the U.S.

$$\Phi_j = \left[e_j \frac{1}{\eta} \left(\frac{w_j}{P_j} + \frac{\pi_{US}}{L_{US} P_j} \right) + (1 - e_j) \left(b_j + \frac{\pi_{US}}{L_{US} P_j} \right) \right] A_j \text{ for } j \in N_{US}. \tag{25}$$

Equation (24) means that the expected indirect utility of living in U.S. state j is the weighted sum of the indirect utilities of being employed/unemployed in U.S. state j, with the weights being the probabilities of being employed/unemployed. Note that an individual foresees that the no-shirking condition will hold and she will make an effort upon being employed.

The amenity shock $\nu_{i,j}$ follows the Fréchet distribution whose cumulative distribution function is $F(\nu) = e^{-\nu^{-\theta}}$, independently and identically across individuals i's and the U.S. states $j \in N_{US}$. The labor force in location j is

$$L_j = \frac{\Phi_j^\theta}{\sum_{k \in N_{US}} \Phi_k^\theta} L_{US} \text{ for } j \in N_{US}. \tag{26}$$

I assume that individual i in any non-U.S. country $j \in N_{NUS}$ also draws the amenity shock $\nu_{i,j}$ from the Fréchet distribution $F(\nu) = e^{-\nu^{-\theta}}$ independently across individuals in country j. This affects none of equilibrium outcomes, because individuals in a non-US country cannot emigrate from their country.

2.3 Welfare

Welfare in the US is given by the ex-ante expected indirect utility before individuals in the U.S. draw idiosyncratic amenity shocks. Let W_{US} be welfare in the U.S., then

$$W_{US} = E\left[\max_{j \in N_{US}} V_{i,j}\right] = E\left[\max_{j \in N_{US}} \Phi_j \nu_{i,j}\right] = \Gamma\left(1 - \frac{1}{\theta}\right)\left(\sum_{j \in N_{US}} \Phi_j^\theta\right)^{\frac{1}{\theta}}, \tag{27}$$

where $\Gamma(\cdot)$ is the gamma function. Welfare in non-U.S. country $j \in N_{NUS}$, W_j, is given by

$$W_j = E[V_{i,j}] = E[\Phi_j \nu_{i,j}] = \Gamma\left(1 - \frac{1}{\theta}\right)\Phi_j, \tag{28}$$

where Φ_j is the baseline expected indirect utility of living in non-U.S. country j which is common to anyone

$$\Phi_j = \left[e_j \frac{1}{\eta}\left(\frac{w_j}{P_j} + \frac{\pi_j}{L_j P_j}\right) + (1 - e_j)\left(b_j + \frac{\pi_j}{L_j P_j}\right)\right] A_j \text{ for } j \in N_{NUS}. \tag{29}$$

2.4 Equilibrium

An equilibrium is defined to be a tuple of price indices $\{P_j\}_{j \in N}$, nominal wages $\{w_j\}_{j \in N}$, employment rates $\{e_j\}_{j \in N}$, aggregate profits $\{\pi_j\}_{j \in N}$, aggregate nominal expenditures $\{X_j\}_{j \in N}$, labor forces in the US states $\{L_j\}_{j \in N_{US}}$ that satisfies equations (12), (15) (with (14)), (20), (**??**), (21), (26) (with (25)). Let $n = |N|$ and $n_{US} = |N_{US}|$, where $|\cdot|$ denotes the cardinality of a set. Then this is a system of $5n + n_{US}$ equations with $5n + n_{US}$ unknowns.

2.5 Exact Hat Algebra

Following Dekle et al. (2007), I characterize a counterfactual equilibrium as a solution to a system of equations for changes in endogenous variables from the baseline equilibrium to a counterfactual equilibrium. Costinot and Rodriguez-Clare (2014) call this equilibrium in changes as exact hat algebra. I consider exogenous changes in productivity and trade costs from the baseline to a counterfactual and assume that any other parameter does not change. See Appendix A.2 for full description of the system of equations for the exact hat algebra.

2.6 Alternative Models

In Section 4, I compare counterfactual results of the model I have exlained so far and two other models. One is a model where all individuals are employed (the full-employment model), and the other is a model where individuals voluntarily choose employment or unemployment (the voluntary-unemployment model). I detail these two alternative models in Appendix C.

3 Taking the Model to Data

This section details data source and how parameters and baseline values in the exact hat algebra are assigned from the data. I consider a 3% increase in China's productivity. I do not have to calibrate productivity, amenity and trade costs to compute this counterfactual because the hat algebra cancels them out. However, some parameter values and the baseline equilibrium values remain to be assigned. For brevity, I describe data only sources and parameter values directly related to unemployment or efficiency wages. All other data sources and parameter values are detailed in Appendix B. I use data from 2012.

For any location j, the employment rate e_j satisfies $e_j = 1 - u_j$, where u_j denotes the unemployment rate.[7] [8] Therefore it is sufficient to have unemployment rates to assign the baseline employment rates to the exact hat algebra. I obtain the unemployment rates in the non-U.S. countries except China at the World Bank Open Data, where the data, in turn, is from the ILOSTAT database of International Labour Organization (ILO). The unemployment rate in China as of 2012 is taken from China Labour Statistical Yearbook 2016.[9] The unemployment rates of the U.S. states come from the U.S. Bureau of Labor Statistics Expanded State Employment Status Demographic Data.

[7] The baseline levels of employment rates $\{e_j\}_{j \in N}$ are needed in (33), (34) and (41).

[8] This unemployment rate is the number of the involuntarily unemployed relative to the labor force. The Bureau of Labor Statistics (BLS) classifies people as unemployed if all of the following conditions hold. (i) "They were not employed during the survey reference week," (ii) "They were available for work during the survey reference week, except for temporary illness," and (iii) "They made at least one specific, active effort to find a job during the 4-week period ending with the survey reference week (see active job search methods) OR they were temporarily laid off and expecting to be recalled to their job." See "Concepts and Definitions (CPS)" at the website of the BLS.

[9] In the data of the World Bank-ILO, the unemployment rate of China in 2012 is 4.6%. In the China Labour Statistical Yearbook 2016, it is 4.1%. I use the value of 4.1%.

I assign the data of nominal unemployment benefits to nominal home production $\{b_j P_j\}_{j\in N}$ in the efficiency-wage model.[10] The data of unemployment benefits in 2012 come from three sources. First, the data of the unemployment benefits in the non-U.S. countries except China come from OECD.Stat Net Replacement Rates in unemployment. The website provides the percentages that an unemployed person can receive from unemployment insurance relative to her previous wage that she received before unemployment. These data are provided for a variety of countries, wage levels and spells of unemployment. For example, I can obtain how much an unemployed single person receives from unemployment insurance if she has been unemployed for 1 year and had received the national average wage before unemployment. I use the value of insurance payment for this profile (single, unemployed for 1 year, previous in-work earnings of the national average wage) to assign the values of unemployment benefits for non-U.S. countries except China. Second, I assume that unemployed people receive 20% of the wage in China, based on the description in Qian (2014). This is because I cannot find the data on unemployment benefits in China from sources of the government or public organizations. Qian (2014) says "Benefits, which could be valid for as long as 104 weeks, can account up to about 20% of average wage." Thus assuming that anyone unemployed receives 20% of the average wage admittedly overstates the unemployment benefits in China. Third, the data of the unemployment benefits in the U.S. states come from UI Replacement Rates Report by the U.S.Department of Labor, Employment and Training Administration. The webpage presents the replacement rate which is defined by the weighted average of

$$\frac{\text{the weekly benefit amounts (WBA)}}{\text{the claimants' normal hourly wage times 40 hours}}.$$ [11]

The replacement rate is the weighted average rather than the simple average across unemployed people because each unemployed person has a different spell of unemployment. The weights are lengths of unemployment spells. I multiply the average nominal wage of a U.S. state by the replacement rate to compute the level of the nominal unemployment benefit in the U.S. state.

The values of the disutility from making an effort η and the probabilities that firms detect shirking $\{q_j\}_{j\in N}$ are needed.[12] I set $\eta = 1.05$, which is admittedly arbitrary. This means that making an effort reduces utility by 5% relative to shirking, if consumption and amenities are held fixed. Later I will compare the result of $\eta = 1.05$ with those of various values of η ranging from 1.01 to 1.1. Rewriting (12), $\eta = 1.05$ and the baseline values of wages, labor forces, and profits[13] together

[10] Nominal home production $\{b_j P_j\}_{j\in N}$ appears in (31), (33) and (41).

[11] This replacement rate is defined to be the "replacement ratio 1" at the webpage.

[12] Detection probabilities $\{q_j\}_{j\in N}$ appear in (31), (33) and (41).

[13] Appendix B describes how I obtain or compute these baseline values.

determine the values of $\{q_j\}_{j\in N}$ by

$$q_j = \frac{(\eta-1)\left(\frac{\pi_j}{L_j}+w_j\right)}{\eta(w_j - b_j P_j)} \quad \text{for } j \in N_{NUS},$$
$$q_j = \frac{(\eta-1)\left(\frac{\pi_{US}}{L_{US}}+w_j\right)}{\eta(w_j - b_j P_j)} \quad \text{for } j \in N_{US}. \tag{30}$$

Table 1 reports the detection probabilities in non-U.S. countries and U.S. states $\{q_j\}_{j\in N}$ associated with $\eta = 1.05$. Among the non-U.S. countries, Switzerland has the highest detection probability of 0.27, whereas China and Italy have the lowest of 0.08. The U.S. states have smaller variation than the non-US countries, ranging from 0.11 in Alaska, Illinois, and New York to 0.16 in Kansas and Iowa.

The baseline values and parameters described in this section, together with those in Appendix B, are used to compute the exact-hat-algebra counterfactuals of the efficiency-wage model. The full-employment model and the voluntary-unemployment model are calibrated in an analogous manner. Appendix D discusses several caveats regarding the quantification of these two alternative models.

4 Counterfactual Results

Using the models in Section 2 and Appendix C, along with the data and parameter values in Section 3, I compute a counterfactual 3% increase in China's productivity. I mainly focus on comparing the efficiency-wage and full-employment models, since the full-employment and voluntary-unemployment models deliver very similar results.

Figure 1 represents the percent changes in real wages across the U.S. states $\left\{\frac{\hat{w}_j}{\hat{P}_j}\right\}_{j\in N_{US}}$ in the efficiency-wage model presented in Section 2. Real wages increase in all the states. States with yellow or light green have larger increases in real wages, while states with dark blue have smaller increases. California and Tennessee have the largest and second largest increases in real wages of 0.11% and 0.09%, respectively. On the other hand, Alaska and Louisiana hava the smallest increases in real wages of about 0.04%. I observe gradation from the West Coast with yellow/light green to the Great Plains and parts of the Midwest with dark blue. This gradation repeatedly appers in the following.

Figure 5 represents the percent changes in real wages across U.S. states in the full-employment model. In the full-employment model, states have smaller increases than in the efficiency-wage model or even decreases in real wages. Indeed, the nationwide employment-weighted average changes in real wages are an order of magnitude different: 0.07% in the efficiency-wage model and 0.008% in the full-employment model.[14] Figure 5 shows a similar gradation pattern to Figure 1:

[14]The U.S. nationwide employment-weighted average changes in real wages is $\frac{\sum_{j\in N_{US}} L_j e_j \frac{\hat{w}_j}{\hat{P}_j}}{\sum_{j\in N_{US}} L_j e_j}$ in the efficiency model

yellow or light green states exhibit larger real-wage increases on the West Coast, while dark blue states experience real-wage decreases or smaller real-wage increases in the Great Plains and parts of the Midwest. Washington has the largest increase of 0.04%, whereas Montana has the largest decrease of 0.005%.

Why do real wages increase more in the efficiency-wage model than in the full-employment model? China's productivity improvement has two primary effects on the U.S. One is that consumer and intermediate-good prices decline in the U.S. The denominator in real wages is the price index, so this affects real wages positively. The other effect is that U.S. firms become less competitive in the global market. In the full-employment model, wages in location i directly depend on global sales of firms in i through the trade-balance or labor-market clearing condition, so the weaker competitiveness negatively affects nominal wages (See (45) in Appendix (C)). But, in the efficiency-wage model, labor markets do not clear. Wages are determined by the no-shirking condition (12), which does not directly depend on global sales of local firms. Therefore, in the efficiency-wage model, nominal wages stay high, and real wages increase more than in the full-employment model.

Figure 2 represents the percent changes in real profits across the US states $\left\{\frac{\hat{\pi}_j}{\hat{P}_j}\right\}_{j\in N_{US}}$ in the efficiency-wage model. Real profits increase in only 6 states.[15] Real profits decrease in the other 44 states. Yellow or light-green states have increases in real profits, and states with the other colors have decreases. California and Tennessee have the largest and second largest increases in real profits of 0.40% and 0.17%, respectively. On the other hand, South Dakota and Wyoming have the largest and second largest decreases in real profits of 0.29% and 0.27%, respectively. In Figure 2, I observe a similar pattern to the map of real-wage changes (Figure 1): gradation from the west coast with yellow or light green to the heartland with dark blue.

Figure 6 represents the percent changes in real profits across the U.S. states in the full-employment model. The geographic pattern and the size of the effects are similar to those in the efficiency-wage model (Figure 2). Indeed, the nationwide population-weighted average changes in real profits are -0.04% in the efficiency-wage model and -0.05% in the full-employment model.[16]

Figure 3 represents the percentage point changes in unemployment across the U.S. states. Unemployment decreases only in Alaska by 0.008 percentage points and increases in the other 49 states. Wyoming has the largest increase in unemployment of 0.17 percentage points. Overall, the U.S. nationwide population-weighted average increase in unemployment is 1.3%.[17] The geographic pattern is similar to Figures 1 and, especially, Figures 2 and 6; the increase in unemployment is smaller on the West Coast and larger in the Great Plains and parts of the Midwest. To see why the pattern in unemployment changes in the efficiency-wage model is similar to the pattern in real-

and $\frac{\sum_{j\in N_{US}} L_j \frac{\hat{w}_j}{\hat{P}_j}}{\sum_{j\in N_{US}} L_j}$ in the full-employment model. See A.2 for the definition of "hat" notations.

[15] These states are California, Tennessee, Nevada, Washington, Minnesota, and Alaska.

[16] The U.S. nationwide population-weighted average change in real profits is $\sum_{j\in N_{US}} \mu_j \frac{\hat{\pi}_j}{\hat{P}_j}$ in both the efficiency-wage model and the full-employment model.

[17] the U.S. nationwide population-weighted average change in unemployment is computed as $\frac{\sum_{j\in N_{US}}(1-e_j\hat{e}_j)L_j\hat{L}_j}{\sum_j(1-e_j)L_j}$.

profit changes in the efficiency-wage model and the full-employment model, I refer to equations (**??**) and (21). Apparently, these two equations are similar. In the labor-market "non-clearing" condition (**??**), given wage w_j and labor force L_j, the employment rate e_j is determined by a fixed share of global sales of firms in location j. In the profit equation (21), nominal profits are also a fixed share of global sales. Therefore, both of (un)employment and profits crucially depend on global sales of local firms, which in turn depend on competitiveness of these firms. However, although wages also depend on global sales through (45) in the full-employment model, wages in the efficiency-wage model, (12), are shielded from changes in global sales.

Figure 4 represents the percent changes in labor forces across the US states in the efficiency-wage model. Labor forces increase in only 8 states including states on the West Coast. Labor forces decrease in the other 42 states. Labor forces increase in yellow and green states and decrease in blue states. California and Tennessee have the first and second largest increases in labor forces of 0.32% and 0.13%, respectively. On the other hand, South Dakota and Wyoming have the first and second largest decreases in labor forces of 0.17% and 0.15%, respectively. Once again, I observe gradation from the West Coast with yellow and light green to the heartland with dark blue. Figure 7 shows a similar geographic pattern with smaller size for the full-employment model.

Table 2 shows changes in equilibrium outcomes across countries for the efficiency-wage model. The first column reports the percent changes in real wages. Real wages increase in all countries. The second column reports the percent changes in real profits. Real profits increase only in 5 out of 27 non-US countries. A productivity increase in China affects other countries' profits in two counteracting ways. One is that, as I said, in terms of relative productivity, producers in other countries become less competitive. The other effect is that intermediate goods from China becomes cheaper, so countries that heavily use Chinese intermediate goods become more competitive. Indeed, South Korea, a neighboring country which imports a lot of Chinese goods, has the second largest increase in real profits only after China itself. But, overall, the former effect of weaker relative productivity dominates and real profits decrease in most countries. The third column reports the percentage point changes in unemployment. Unemployment decreases only in China and increases in the other 26 non-U.S. countries. In China, the unemployment rate decreases by 3.4 percentage points. The fourth column reports the percent changes in welfare. Welfare increases in only 10 countries out of 28 countries (including the U.S.), while welfare decreases in the other 18 countries. This result is at odds with Caliendo et al. (2019), for Caliendo et al. (2019) claim that the China shock increases welfare in all countries in their calibration.

In Appendix E, Table 4 shows the percent changes in the US welfare in response to the 5% increase in China's productivity for different values of disutility of making an effort: $\eta = 1.01, 1.03, 1.05, 1.07, 1.1$. Since detection probabilities $\{q_j\}$ are adjusted for each value of η, aggregate U.S. welfare stays the same across different values of η.

I turn to sources of heterogeneity driving heterogeneous effects of China's productivity improvement across U.S. states. I have observed gradation; real wages and real profits increase more on the west coast than in the heartland; unemployment increases less (or even decreases) on the West Coast than in the heartland. Trade exposure to China plays a key role. Since trade is imports and exports, there are two measures of trade exposure in the model. One is import intensity: import values from China relative to total expenditure, $\gamma_{k,j}$ in (35). The other is export intensity: export values to China relative to total sales, $\alpha_{j,k}$ in (37).

California has the highest import intensity from China of 8% among the U.S. states. I redo the counterfactual excersise replacing the U.S. states' baseline import intensity with California's level.[18] In Appendix E, Figures 8, 9, 10, 11, and Table 5 show results. California no longer stands out. Gradation from the west coast to the heartland becomes weakened. Therefore, these maps strongly suggest that the U.S. internal geography of the China-shock effects is largely shaped by import intensity across states in the quantitative model.

Recall that if China's productivity increases by 3%, unemployment decreases only in Alaska among the U.S. states (Figure 3). What drives this? Actually, Alaska has the highest export intensity to China of 6% among the U.S. states. I redo the counterfactual excersise replacing the U.S. states' baseline export intensity with Alaska's level.[19] In Appendix E, Figures 12, 13, 14, 15, and Table 6 show results. Gradation from the west coast to the heartland still remains, implying this gradation is not driven by export intensity. In 14 about unemployment changes, Alaska no longer stands out. Therefore, the reason that unemployment decreases only in Alaska in Figure 3 is its particularly high export intensity to China.[20]

Caliendo et al. (2019) is an influential paper which models nonemployment as an alternative in (voluntary) discrete choices. Then, how are counterfactual predictions of my efficiency-wage model different from a model where individuals voluntarily choose unemployment? I develop a static spatial model in which each U.S. resident chooses her location and employment status (employed or unemployed) in a descrete choice framework. See Appendix C for details of this model. In Appendix E, Figures 20, 21, 22, 23, and Table 8 report counterfactual outcomes of a 3% increase in China's productivity relative to the baseline equilibrium for this voluntary-unemployment model. These results demonstrate that counterfactual predictions of the voluntary-unemployment model are very similar to those of the full-employment model. Therefore, although I appreciate a margin of voluntary unemployment, I suspect that introducing unemployment as an alternative in discrete choices does not substantially change counterfactual predictions at least in a static quantitative spatial model with one production sector.

Finally, I examine whether baseline (initial) unemployment levels matter for unemployment responses to China's productivity improvement. Nevada has the highest unemployment rate, at 11%. I therefore hypothetically set the baseline unemployment rate in all U.S. states equal to Nevada's level. In Appendix E, Figures 16, 17, 18, 19, and Table 7 report the results. These results are very similar to those from the efficiency-wage model using the unemployment rates observed in the data. In particular, a comparison of Figures 3 and 18 shows that changes in unemployment are nearly identical. This implies that baseline unemployment levels do not materially affect the

[18]The U.S. states' import intensity on other countries and U.S. states are rescaled to sum to one.

[19]The U.S. states' export intensity on other countries and U.S. states are rescaled to sum to one.

[20]Alaska, Washington, and Louisiana have the first, second, and third highest export intensity to China of 5.6%, 4.5%, and 2.5%, respectively.

counterfactual predictions for unemployment changes.

5 Conclusion

How do foreign shocks affect the spatial distribution of real wages and involuntary unemployment? What are the welfare effects of foreign shocks in the presence of involuntary unemployment? To answer these questions, I develop a quantitative trade and spatial model including involuntary unemployment. The model features efficiency wages, which generate unemployment.

Calibrating the model for 27 countries and all states in the United States, I compute the counterfactual of a 3 % increase in China's productivity. The model highlights heterogeneous effects of this shock which are largely driven by state-level import intensity from China. Unemployment rates increase in all US states except Alaska. Real wages increase in all US states, and the total welfare in the US increases.

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Figure 1: % Changes in Real Wages in the US States in Response to a 3% Increase in China's Productivity: the Efficiency-Wage Model

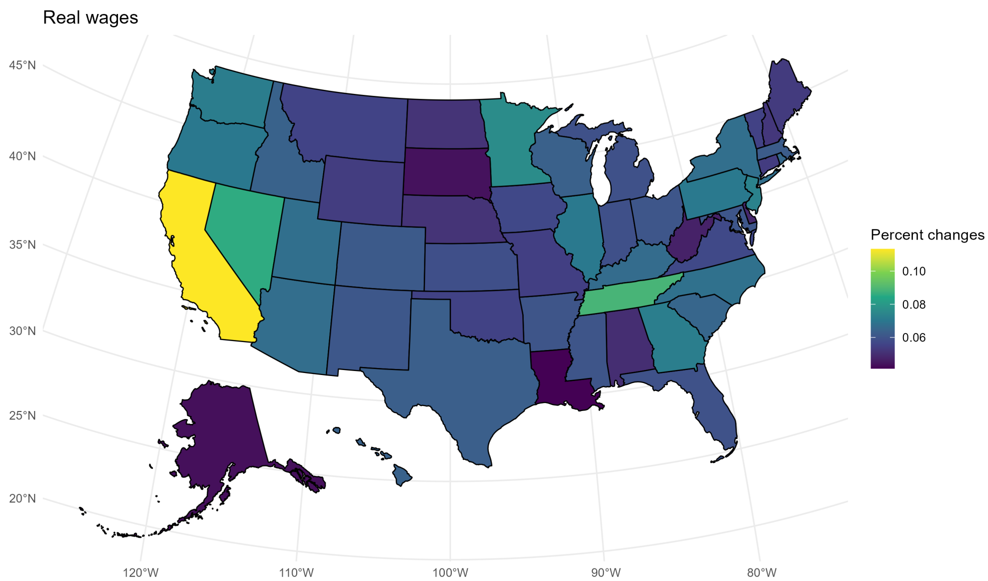

Figure 2: % Changes in Real Profits in the US States in Response to a 3% Increase in China's Productivity: the Efficiency-Wage Model

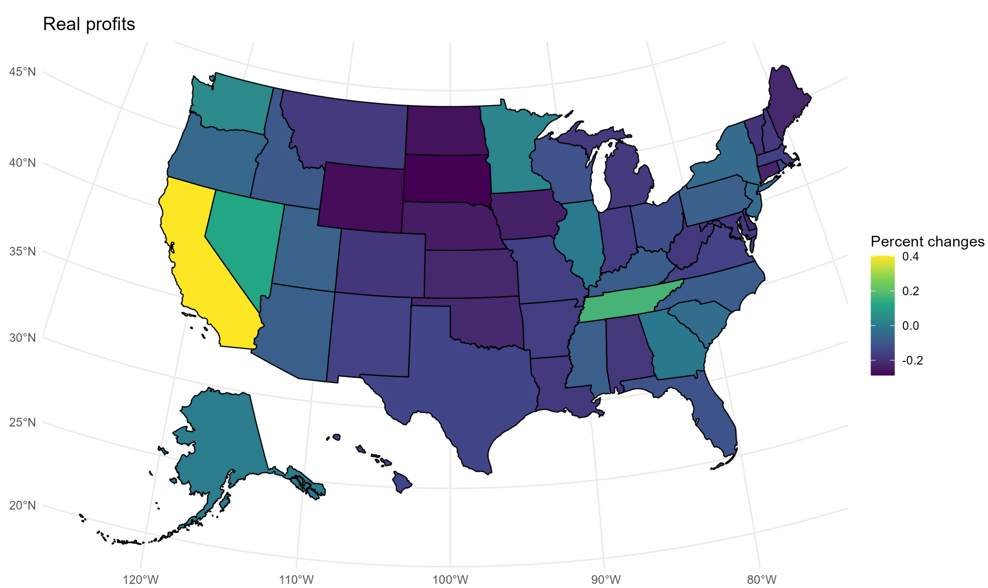

Figure 3: Percentage Point Changes in Unemployment in the US States in Response to a 3% Increase in China's Productivity: the Efficiency-Wage Model

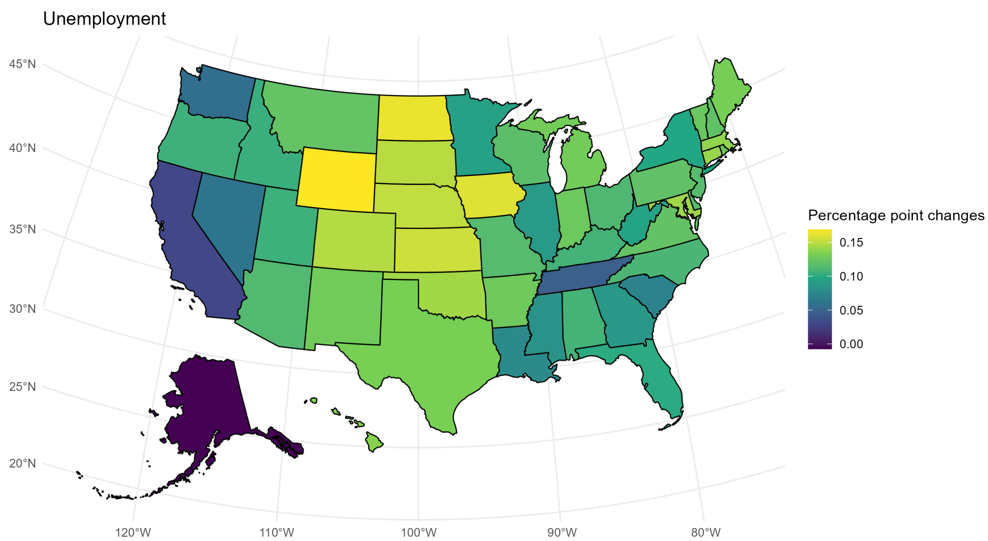

Figure 4: % Changes in Labor Forces in the US States in Response to a 3% Increase in China's Productivity: the Efficiency-Wage Model

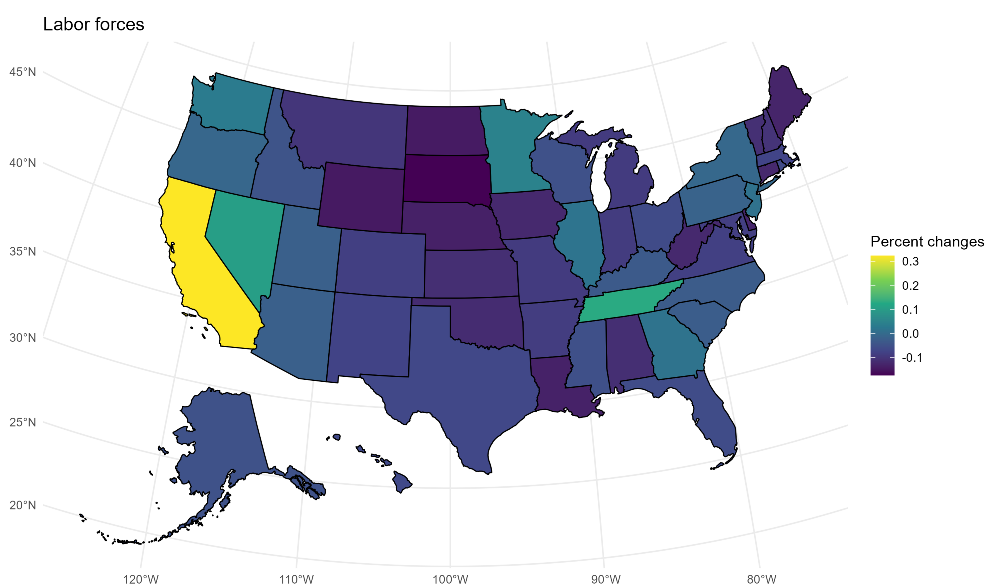

Figure 5: % Changes in Real Wages in the US States in Response to a 3% Increase in China's Productivity: the Full-Employment Model

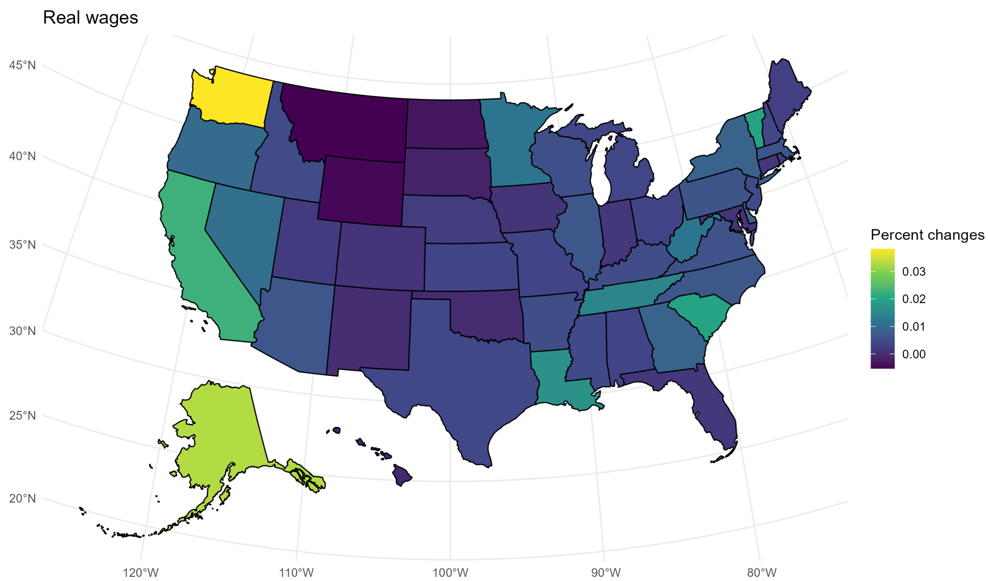

Figure 6: % Changes in Real Profits in the US States in Response to a 3% Increase in China's Productivity: the Full-Employment Model

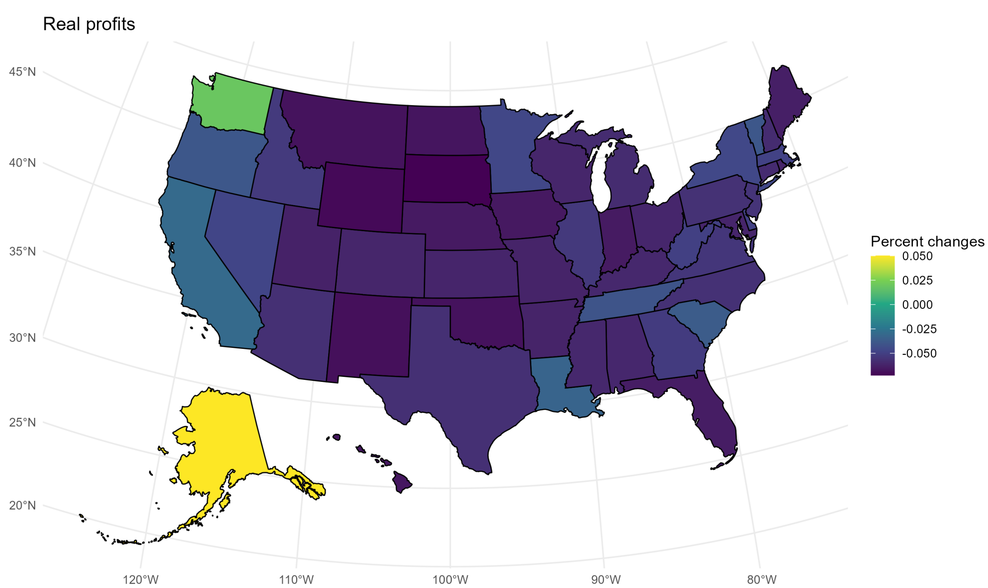

Figure 7: % Changes in Labor Forces in the US States in Response to a 3% Increase in China's Productivity: the Full-Employment Model

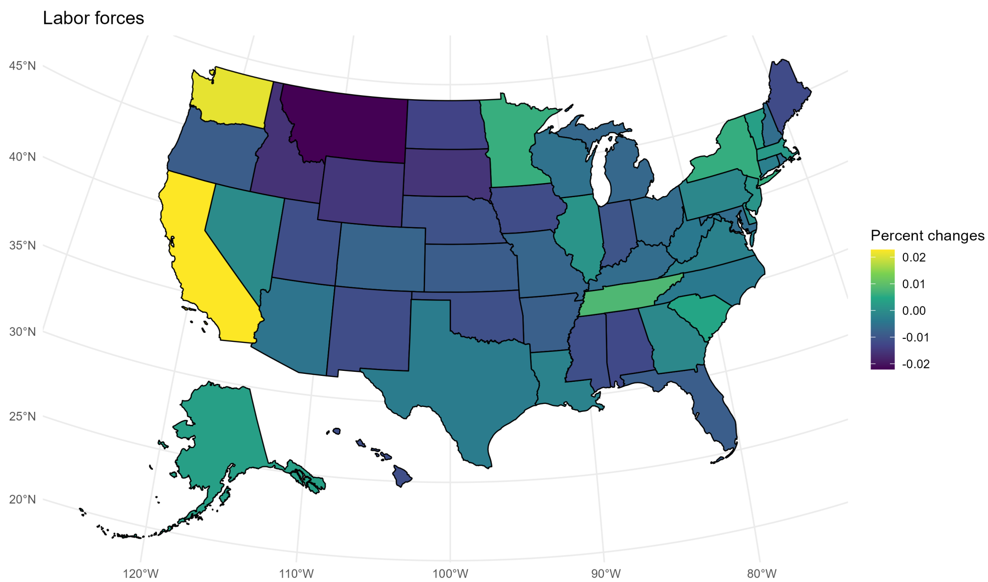

Table 1: Detection Probabilities for non-U.S. Countries and U.S. States: the Efficiency-Wage Model with $\eta = 1.05$

Country/State	Detection Probability	State	Detection Probability
Australia	0.10	Illinois	0.11
Belgium	0.21	Indiana	0.15
Canada	0.09	Iowa	0.16
China	0.08	Kansas	0.16
Czech Republic	0.14	Kentucky	0.15
Denmark	0.19	Louisiana	0.12
Estonia	0.15	Maine	0.15
Finland	0.18	Maryland	0.13
France	0.22	Massachusetts	0.13
Germany	0.18	Michigan	0.14
Greece	0.10	Minnesota	0.14
Hungary	0.18	Mississippi	0.14
Ireland	0.12	Missouri	0.13
Israel	0.09	Montana	0.15
Italy	0.08	Nebraska	0.14
Japan	0.12	Nevada	0.14
Korea, South	0.09	New Hampshire	0.12
Netherlands	0.26	New Jersey	0.14
New Zealand	0.10	New Mexico	0.15
Norway	0.22	New York	0.11
Poland	0.14	North Carolina	0.15
Slovakia	0.11	North Dakota	0.14
Slovenia	0.11	Ohio	0.13
Spain	0.17	Oklahoma	0.15
Sweden	0.14	Oregon	0.14
Switzerland	0.27	Pennsylvania	0.15
United Kingdom	0.11	Rhode Island	0.16
Alabama	0.13	South Carolina	0.14
Alaska	0.11	South Dakota	0.14
Arizona	0.12	Tennessee	0.12
Arkansas	0.16	Texas	0.14
California	0.12	Utah	0.15
Colorado	0.14	Vermont	0.15
Connecticut	0.12	Virginia	0.12
Delaware	0.12	Washington	0.14
Florida	0.13	West Virginia	0.13
Georgia	0.13	Wisconsin	0.14
Hawaii	0.15	Wyoming	0.15
Idaho	0.15		

Table 2: Changes in Equilibrium Outcomes of Countries in Response to a 3% Increase in China's Productivity: the Efficiency-Wage Model with $\eta = 1.05$

Country	Real Wage %	Real Profits %	Unemployment p.p.	Walfare %
Australia	0.08	-0.02	0.09	0.00
Belgium	0.07	-0.07	0.13	-0.02
Canada	0.06	-0.05	0.10	-0.03
China	4.42	8.07	-3.35	7.46
Czech Republic	0.11	0.06	0.05	0.07
Denmark	0.06	-0.14	0.18	-0.05
Estonia	0.08	0.00	0.07	0.02
Finland	0.06	-0.10	0.15	-0.04
France	0.06	-0.13	0.18	-0.05
Germany	0.07	-0.06	0.12	-0.01
Greece	0.04	-0.08	0.09	-0.06
Hungary	0.04	-0.06	0.09	-0.05
Ireland	0.06	-0.08	0.12	-0.04
Israel	0.05	-0.05	0.10	-0.04
Italy	0.04	-0.04	0.07	-0.04
Japan	0.07	-0.03	0.10	0.00
Korea, South	0.14	0.09	0.05	0.10
Netherlands	0.08	0.01	0.07	0.05
New Zealand	0.08	-0.01	0.09	0.01
Norway	0.06	-0.16	0.20	-0.06
Poland	0.07	-0.05	0.10	-0.01
Slovakia	0.09	0.01	0.07	0.02
Slovenia	0.06	-0.05	0.10	-0.03
Spain	0.06	-0.14	0.15	-0.05
Sweden	0.04	-0.12	0.15	-0.07
Switzerland	0.07	-0.16	0.22	-0.04
United Kingdom	0.05	-0.09	0.13	-0.05
United States				0.09

Table 3: Changes in Equilibrium Outcomes of Countries in Response to a 3% Increase in China's Productivity: the Full-Employment Model

Country	Real Wage %	Real Profits %	Walfare %
Australia	0.02	0.10	0.04
Belgium	0.01	-0.04	-0.01
Canada	0.01	-0.04	-0.01
China	4.62	4.04	4.45
Czech Republic	0.01	-0.04	-0.02
Denmark	0.00	-0.04	-0.01
Estonia	0.01	-0.06	-0.02
Finland	0.01	-0.03	-0.01
France	0.00	-0.05	-0.02
Germany	0.01	-0.01	0.00
Greece	-0.00	-0.07	-0.03
Hungary	-0.00	-0.07	-0.05
Ireland	0.01	-0.03	-0.00
Israel	0.01	-0.03	-0.01
Italy	0.00	-0.05	-0.02
Japan	0.01	0.03	0.02
Korea, South	0.06	0.21	0.11
Netherlands	0.01	-0.04	-0.01
New Zealand	0.01	0.04	0.02
Norway	0.00	-0.05	-0.02
Poland	0.00	-0.06	-0.02
Slovakia	0.01	-0.02	-0.00
Slovenia	0.00	-0.05	-0.02
Spain	0.00	-0.06	-0.02
Sweden	0.00	-0.04	-0.01
Switzerland	0.01	0.01	0.01
United Kingdom	0.00	-0.05	-0.02
United States			-0.01

A Details of the Model

A.1 Proof of the No-Shirking Wage

First, note that in any firm $\omega \in [0,1]$ in location j, all employees make an effort if its wage $w_j(\omega)$ is strictly higher than (12). All employees of ω shirk if its wage $w_j(\omega)$ is strictly lower than (12).

Now I prove that in equilibrium, the nominal wage in location j satisfies (12). That is, any firm $\omega \in [0,1]$ offers the wage (12). I show this by the way of contradiction. Let w_j be the wage defined by (12), and $w_j(\omega)$ generically denote the wage that firm ω in location j offers. Suppose, to the contrary, that there exists firm ω such that $w_j(\omega) \neq w_j$. On the one hand, suppose that $w_j(\omega) > w_j$. Then firm ω would have an incentive to decrease the wage to, say, $w'_j(\omega) \in [w_j, w_j(\omega)) \neq \emptyset$. This is because, if the firm reduces the wage to $w'_j(\omega)$, any employee would make an effort so that the firm would sustain the production level as of $w_j(\omega)$, and the firm would reduce the labor cost. On the other hand, suppose that $w_j(\omega) < w_j$. Then no employee makes an effort, and by the production function (10), the production level is zero. The profits are non-positive. Therefore the firm has an incentive to increase the wage to $w'_j(\omega) \in [w_j, \infty)$, so that the firm can produce a positive amount of the product. Because of monopolistic competition with a fixed number of firms, any firm makes positive profits as long as it produces a positive amount. □

In equilibrium, the measure of employees who shirk is zero for the wage (12). Suppose, to the contrary, that a positive measure of employees of firm $\omega \in [0,1]$ shirk for the wage (12). Then the firm would increase the wage slightly, so that any employee makes an effort, then the production level and the profits would discontinuously increase. Therefore the case where a positive measure of employees shirk for the wage (12) is not sustained in equilibrium. In other words, in equilibrium, if the $l_j(\omega)$ measure of workers are hired by firm $\omega \in [0,1]$ in location j, the same $l_j(\omega)$ measure of employees make an effort, for the nominal wage (12). □

A.2 System of Equations for the Exact Hat Algebra

For a generic variable x, let $\hat{x} = \frac{x'}{x}$ be the change in the variable x from the baseline equilibrium to a counterfactual equilibrium, where x' and x are the counterfactual and baseline value of the variable, respectively.

Taking the ratio of (12) between a counterfactual and the baseline, I obtain the changes in no-shirking wages

$$\begin{aligned} \hat{w}_j &= \frac{\eta q_j b_j P_j \hat{P}_j + (\eta - 1)\frac{\pi_j \hat{\pi}_j}{L_j}}{\eta q_j b_j P_j + (\eta - 1)\frac{\pi_j}{L_j}} \quad \text{for } j \in N_{NUS}, \\ \hat{w}_j &= \frac{\eta q_j b_j P_j \hat{P}_j + (\eta - 1)\frac{\pi_{US} \hat{\pi}_{US}}{L_{US}}}{\eta q_j b_j P_j + (\eta - 1)\frac{\pi_{US}}{L_{US}}} \quad \text{for } j \in N_{US}, \end{aligned} \tag{31}$$

where $\hat{\pi}_{US}$ is the change in the US total profits, that is,

$$\hat{\pi}_{US} = \frac{\pi'_{US}}{\pi_{US}} = \frac{\sum_{j \in N_{US}} \pi_j \hat{\pi}_j}{\sum_{j \in N_{US}} \pi_j}. \tag{32}$$

Taking the ratio of (14) between a counterfactual and the baseline, the changes in aggregate nominal incomes are expressed as

$$\begin{aligned} \hat{I}_j &= \frac{e_j \hat{e}_j \left(w_j \hat{w}_j + \frac{\pi_j \hat{\pi}_j}{L_j} \right) + (1 - e_j \hat{e}_j) \left(b_j P_j \hat{P}_j + \frac{\pi_j \hat{\pi}_j}{L_j} \right)}{e_j \left(w_j + \frac{\pi_j}{L_j} \right) + (1 - e_j) \left(b_j P_j + \frac{\pi_j}{L_j} \right)} \quad \text{for } j \in N_{NUS}, \\ \hat{I}_j &= \frac{e_j \hat{e}_j \hat{L}_j \left(w_j \hat{w}_j + \frac{\pi_{US} \hat{\pi}_{US}}{L_{US}} \right) + (1 - e_j \hat{e}_j) \hat{L}_j \left(b_j P_j \hat{P}_j + \frac{\pi_{US} \hat{\pi}_{US}}{L_{US}} \right)}{e_j \left(w_j + \frac{\pi_{US}}{L_{US}} \right) + (1 - e_j) \left(b_j P_j + \frac{\pi_{US}}{L_{US}} \right)} \quad \text{for } j \in N_{US}. \end{aligned} \tag{33}$$

Then, taking the ratio of (15) between a counterfactual and the baseline, the changes in aggregate expenditures are

$$\begin{aligned} \hat{X}_j &= \frac{I_j \hat{I}_j + \frac{1-\beta}{\beta} w_j \hat{w}_j e_j \hat{e}_j L_j}{I_j + \frac{1-\beta}{\beta} w_j e_j L_j} \quad \text{for } j \in N_{NUS}, \\ \hat{X}_j &= \frac{I_j \hat{I}_j + \frac{1-\beta}{\beta} w_j \hat{w}_j e_j \hat{e}_j L_j \hat{L}_j}{I_j + \frac{1-\beta}{\beta} w_j e_j L_j} \quad \text{for } j \in N_{US}. \end{aligned} \tag{34}$$

For any pair of locations $(k, j) \in N \times N$, define location k's share in location j's imports, $\gamma_{k,j}$, by

$$\gamma_{k,j} = \frac{X_{k,j}}{\sum_{n \in N} X_{n,j}}, \tag{35}$$

where $X_{n,j}$ denotes the aggregate trade value from location n to location j. Taking the ratio of (20) between a counterfactual and the baseline, I have changes in price indices

$$\hat{P}_j = \left[\sum_{k \in N} \gamma_{k,j} \hat{t}_{k,j}^{1-\sigma} \hat{w}_k^{\beta(1-\sigma)} \hat{P}_k^{(1-\beta)(1-\sigma)} \hat{z}_k^{\sigma-1} \right]^{\frac{1}{1-\sigma}} \quad \text{for } j \in N. \tag{36}$$

For any pair of locations $(k, j) \in N \times N$, define location k's share in location j's exports, $\alpha_{j,k}$, by

$$\alpha_{j,k} = \frac{X_{j,k}}{\sum_{n \in N} X_{j,n}}. \tag{37}$$

Taking the ratio of (**??**) between a counterfactual and the baseline, I have changes in employment

$$\begin{aligned}\hat{e}_j &= \hat{w}_j^{\beta(1-\sigma)-1}\hat{P}_j^{(1-\beta)(1-\sigma)}\hat{z}_j^{\sigma-1}\sum_{k\in N}\alpha_{j,k}\hat{t}_{j,k}^{1-\sigma}\hat{P}_k^{\sigma-1}\hat{X}_k \text{ for } j\in N_{NUS},\\ \hat{e}_j &= \hat{w}_j^{\beta(1-\sigma)-1}\hat{P}_j^{(1-\beta)(1-\sigma)}\hat{z}_j^{\sigma-1}\hat{L}_j^{-1}\sum_{k\in N}\alpha_{j,k}\hat{t}_{j,k}^{1-\sigma}\hat{P}_k^{\sigma-1}\hat{X}_k \text{ for } j\in N_{US}\end{aligned} \tag{38}$$

Taking the ratio of (21) between a counterfactual and the baseline, I obtain changes in aggregate profits

$$\hat{\pi}_j = \hat{w}_j^{\beta(1-\sigma)}\hat{P}_j^{(1-\beta)(1-\sigma)}\hat{z}_j^{\sigma-1}\sum_{k\in N}\alpha_{j,k}\hat{t}_{j,k}^{1-\sigma}\hat{P}_k^{\sigma-1}\hat{X}_k \text{ for } j\in N. \tag{39}$$

Let $\mu_j=\frac{L_j}{L_{US}}$ for any $j\in N_{US}$, that is, the share of state j in the total labor force in the US. Then taking the ratio of (26) between a counterfactual and the baseline, I have

$$\hat{L}_j=\hat{\mu}_j=\frac{\hat{\Phi}_j^{\theta}}{\sum_{k\in N_{US}}\mu_k\hat{\Phi}_k^{\theta}} \text{ for } j\in N_{US}, \tag{40}$$

where

$$\hat{\Phi}_j=\frac{1}{\hat{P}_j}\left[\frac{e_j\hat{e}_j\frac{1}{\eta}\left(w_j\hat{w}_j+\frac{\pi_{US}\hat{\pi}_{US}}{L_{US}}\right)+(1-e_j\hat{e}_j)\left(b_jP_j\hat{P}_j+\frac{\pi_{US}\hat{\pi}_{US}}{L_{US}}\right)}{e_j\frac{1}{\eta}\left(w_j+\frac{\pi_{US}}{L_{US}}\right)+(1-e_j)\left(b_jP_j+\frac{\pi_{US}}{L_{US}}\right)}\right] \text{ for } j\in N_{US}. \tag{41}$$

Taking the ratio of (27), the change in the US welfare from the baseline to a counterfactual, $\hat{W}_{US}$, is

$$\hat{W}_{US}=\left(\sum_{k\in N_{US}}\mu_k\hat{\Phi}_k^{\theta}\right)^{\frac{1}{\theta}}.$$

Taking the ratio of (28), the change in welfare in non-US country j from the baseline to a counterfactual, $\hat{W}_j$, is

$$\hat{W}_j=\hat{\Phi}_j,$$

where, by taking the ratio of (29) between a counterfactual and the baseline, $\hat{\Phi}_j$ is

$$\hat{\Phi}_j=\frac{e_j\hat{e}_j\frac{1}{\eta}\left(\frac{w_j\hat{w}_j}{\hat{P}_j}+\frac{\pi_j\hat{\pi}_j}{L_j\hat{P}_j}\right)+(1-e_j\hat{e}_j)\left(b_jP_j+\frac{\pi_j\hat{\pi}_j}{L_j\hat{P}_j}\right)}{e_j\frac{1}{\eta}\left(w_j+\frac{\pi_j}{L_j}\right)+(1-e_j)\left(b_jP_j+\frac{\pi_j}{L_j}\right)}$$

for $j\in N_{NUS}$.

An equilibrium in changes is defined to be a tuple of changes in price indices $\{\hat{P}_j\}_{j\in N}$, nominal wages $\{\hat{w}_j\}_{j\in N}$, employment rates $\{\hat{e}_j\}_{j\in N}$, aggregate profits $\{\hat{\pi}_j\}_{j\in N}$, aggregate nominal expenditures $\{\hat{X}_j\}_{j\in N}$ and labor forces in the US states $\{\hat{L}_j\}_{j\in N_{US}}$ that satisfies equations (31), (34) (with (33)), (36), (38), (39), (40) (with (41)). This is a system of $5n+n_{US}$ equations with $5n+n_{US}$ unknowns. I refer to this system of equations as the exact hat algebra, following Costinot and Rodriguez-Clare (2014).

B Details on the Quantification

B.1 Data Souces and Parameter Values

Following Broda and Weinstein (2006), I set the elasticity of substitution $\sigma = 4$.[21] [22] The elasticity of labor forces with respect to appeal θ is set to be 1.5, following Tombe and Zhu (2019).[23]

I collect trade values among 27 non-U.S. countries and the 50 U.S. states as of 2012.[24] The trade values among the 77 locations constitute the 77×77 matrix whose (j,k) element is the trade value from location j to location k, $X_{j,k}$. Trade values between non-U.S. countries come from the United Nations comtrade database. Trade values between the U.S. states and the non-U.S. countries come from the U.S. Census Bureau U.S. Import and Export Merchandise trade statistics on USA trade online. Trade values between the U.S. states are from the commodity flow survey that is uploaded on the U.S. Census Bureau American Fact Finder. A problem is that 288 values out of $50 \times 50 = 2500$ are missing in the U.S. inter-state trade data. I impute 194 missing values out of 288 using trade values as of 2007 and the U.S. nationwide nominal GDP growth from 2007 to 2012. See B.2 for details of this imputation.

Given the parameter value $\sigma = 4$ and trade values, I back out aggregate profits in each location using

$$\pi_j = \frac{1}{\sigma} \sum_{k \in N} X_{j,k}$$

for any $j \in N$. This equation is implied by (21).

The nominal wages of all the non-US countries but China come from OECD's data of average annual wages as of 2012.[25] The average nominal wages of the OECD countries are measured in national currency units such as euros for EU and yens for Japan, and I translate them in terms of the U.S. dollars with the nominal exchange rates in 2012. The nominal wage in China as of 2012 is taken from China Labour Statistical Yearbook 2016. Again I translate it in terms of the US dollars with the nominal exchange rate. For the nominal wages for the U.S. states, I use the data of average annual pays from Bureau of Labor Statistics Quarterly Census of Employment and Wages.

Labor forces in the non-U.S. countries come from the World Bank.[26] Labor forces in the U.S. states are taken from U.S. Bureau of Labor Statistics Local Area Unemployment Statistics.

I need the labor share in total costs β.[27] The labor market unclearing condition (**??**) implies

$$\beta = \frac{\sigma}{\sigma - 1} \frac{w_j e_j L_j}{\sum_{k \in N} X_{j,k}}$$

[21] The elasticity of substitution σ is in (36), (38) and (39).

[22] The mean of the point estimates for the elasticities of substitution for U.S. imports across SITC-3 industries is 4, as in pp. 568, Table IV of Broda and Weinstein (2006). The elasticity of substitution varies across SITC-3 industries from 1.2 of thermionic cold cathode to 22.1 of crude oil.

[23] θ appears in in (40).

[24] Trade values are needed in (35) and (37).

[25] The baseline levels of nominal wages $\{w_j\}_{j \in N}$ are needed in (33), (34), (41).

[26] The baseline levels of labor forces $\{L_j\}_{j \in N}$ are needed in (33), (34), (38) and (41).

[27] β appears is in (34), (36), (38) and (39)

for any $j \in N$. Since all values on the right-hand side are already given, I could compute the value of the right-hand side. However, the value of the right-hand side varies for different locations j's. I take a simple average of the right-hand side across locations. That is, I compute β by

$$\beta = \frac{1}{n} \sum_{j \in N} \frac{\sigma}{\sigma - 1} \frac{w_j e_j L_j}{\sum_{k \in N} X_{j,k}} = 0.65.$$

B.2 Zero Trade Values

Suppose that the trade value from US state k to US state j as of 2012, $X_{k,j}^{2012}$, is missing. Then if I have the trade value from k to j as of 2007, say $X_{k,j}^{2007}$, I fill the missing value $X_{k,j}^{2012}$ with

$$X_{k,j}^{2007} \times g_{US}^{2007,2012},$$

where $g_{US}^{2007,2012} = 1.12$ is the growth rate of the US nominal GDP from 2007 to 2012. This procedure fills 194 missing values out of 288. I set zeros for the remaining 94 missing trade values among the US states, which are 3.8% of all the 2500 inter-state trade values. Some of international trade values and trade values between non-US countries and US states are zeros or missing in the data sources. I set zeros for missing values in them. After all, I have 129 zero values in the 77×77 whole trade value matrix. That is, 2% of the trade values are zeros in my data.

C Details on Alternative Models

In Section 4, I compare counterfactual results of the efficiency-wage model with those of the full-employment model and the voluntary-unemployment model. In the following, I describe the latter two models.

C.1 Full-Employment Model

I consider an economy without unemployment. (The labor in location j, L_j, is set equal to the employment, not labor force, in the quantification of the full employment model.) I describe only assumptions and equilibrium conditions that differ from those in the efficiency-wage model in Section 2.

I set $\tilde{\eta}_i = 1$ in the utility function (1) because I do no longer have to consider individuals' choices of shirking or making an effort; everyone is hired and makes an effort.

Since I do not consider unemployment, the individual-level income (3) is simplified as

$$\tilde{w}_{i,j} = \begin{cases} w_j + \frac{\pi_j}{L_j} & \text{for } j \in N_{NUS}, \\ w_j + \frac{\pi_{US}}{L_{US}} & \text{for } j \in N_{US}. \end{cases} \tag{42}$$

The aggregate income in location j (14) is also simplified as

$$I_j = \begin{cases} L_j\left(w_j + \frac{\pi_j}{L_j}\right) & \text{for } j \in N_{NUS}, \\ L_j\left(w_j + \frac{\pi_{US}}{L_{US}}\right) & \text{for } j \in N_{US}. \end{cases} \tag{43}$$

Then the "appeal" or "attractiveness" of location j (25) is

$$\Phi_j = \left(\frac{w_j}{P_j} + \frac{\pi_{US}}{L_{US}P_j}\right)A_j. \tag{44}$$

The most important difference from the efficiency-wage model is that wages are determined by the trade balance conditions (or the labor market clearing conditions in a usual general equilibrium model of international trade)

$$w_j L_j = \beta\frac{\sigma-1}{\sigma}\sum_{k\in N}\left(\frac{\sigma}{\sigma-1}\frac{w_j^{\beta}P_j^{1-\beta}t_{j,k}}{z_j P_k}\right)^{1-\sigma} X_k. \tag{45}$$

The aggregate expenditure in location $j \in N$ (15) is simplified as

$$X_j = I_j + \frac{1-\beta}{\beta}w_j L_j. \tag{46}$$

An equilibrium is a tuple of $\{P_j\}_{j\in N}$, $\{w_j\}_{j\in N}$, $\{\pi_j\}_{j\in N}$, $\{X_j\}_{j\in N}$, $\{I_j\}_{j\in N}$, $\{L_j\}_{j\in N_{US}}$, $\{\Phi_j\}_{j\in N_{US}}$ such that (46), (43), (20), (45), (26), (44), (21).

An equilibrium in changes (exact hat algebra) for this model is characterized by a tuple of $\{\hat{P}_j\}_{j\in N}$, $\{\hat{w}_j\}_{j\in N}$, $\{\hat{\pi}_j\}_{j\in N}$, $\{\hat{X}_j\}_{j\in N}$, $\{\hat{I}_j\}_{j\in N}$, $\{\hat{L}_j\}_{j\in N_{US}}$, $\{\hat{\Phi}_j\}_{j\in N_{US}}$ satisfying (36), (39), (40), and

$$\hat{X}_j = \begin{cases} \frac{I_j\hat{I}_j + \frac{1-\beta}{\beta}w_j\hat{w}_j L_j}{I_j + \frac{1-\beta}{\beta}w_j L_j} & \text{for } j \in N_{NUS}, \\ \frac{I_j\hat{I}_j + \frac{1-\beta}{\beta}w_j\hat{w}_j L_j\hat{L}_j}{I_j + \frac{1-\beta}{\beta}w_j L_j} & \text{for } j \in N_{US}, \end{cases} \tag{47}$$

$$\hat{I}_j = \begin{cases} \frac{w_j\hat{w}_j + \frac{\pi_j\hat{\pi}_j}{L_j}}{w_j + \frac{\pi_j}{L_j}} & \text{for } j \in N_{NUS}, \\ \hat{L}_j\frac{w_j\hat{w}_j + \frac{\pi_{US}\hat{\pi}_{US}}{L_{US}}}{w_j + \frac{\pi_{US}}{L_{US}}} & \text{for } j \in N_{US}. \end{cases} \tag{48}$$

$$\hat{w}_j = \left[\frac{1}{\hat{L}_j}\hat{P}_j^{(1-\beta)(1-\sigma)}\hat{z}_j^{\sigma-1}\sum_k(\alpha_{j,k}\hat{t}_{j,k}^{1-\sigma})\hat{X}_k\right]^{\frac{1}{1-\beta(1-\sigma)}}, \tag{49}$$

$$\hat{\Phi}_j = \frac{1}{\hat{P}_j}\cdot\frac{w_j\hat{w}_j + \frac{\pi_{US}\hat{\pi}_{US}}{L_{US}}}{w_j + \frac{\pi_{US}}{L_{US}}} \text{ for } j \in N_{US}. \tag{50}$$

C.2 Voluntary-Unemployment Model

I develop a model where individuals voluntarily choose employment or unemployment as well as locations. In this economy, no one is involuntarily unemployed. I call voluntary unemployment, not voluntary nonemployment, because I use (involuntary) unemployment rates for the sake of apple-to-apple comparison with the efficiency-wage model which is calibrated with unemployment rates. In the following, I describe only assumptions and equilibrium conditions that differ from those in the efficiency-wage model in Section 2.

There are two employment statuses: employed ($\xi = 1$) or unemployed ($\xi = 0$). Instead of (1), individual i's preferences are represented by

$$U_{i,j,\xi} = C_{i,j,\xi} A_j \nu_{i,j,\xi}, \tag{51}$$

where $C_{i,j,\xi}$ is consumption of individual i in location j and employment status ξ, and $\nu_{i,j,\xi}$ denotes individual i's idiosyncratic preference shock for location j and employment status ξ.

I consider 4 cases for individual i's nominal income in location j and employment status ξ, $\tilde{w}_{i,j,\xi}$,

$$\tilde{w}_{i,j,\xi} = \begin{cases} w_j + \frac{\pi_j}{L_j} & \text{if } \xi = 1 \ \& \ j \in N_{NUS}, \\ b_j P_j + \frac{\pi_j}{L_j} & \text{if } \xi = 0 \ \& \ j \in N_{NUS}, \\ w_j + \frac{\pi_{US}}{L_{US}} & \text{if } \xi = 1 \ \& \ j \in N_{US}, \\ b_j P_j + \frac{\pi_{US}}{L_{US}} & \text{if } \xi = 0 \ \& \ j \in N_{US}. \end{cases} \tag{52}$$

This replaces the nominal income equation (3) in the efficiency-wage model. Then individual i's demand for variety ω shipped from location k to j is

$$C_{i,k,j,\xi}(\omega) = \left(\frac{p_k(\omega) t_{k,j}}{P_j}\right)^{-\sigma} \left(\frac{\tilde{w}_{i,j,\xi}}{P_j}\right), \tag{53}$$

which replaces (5). The budget constraint is

$$P_j C_{i,j,\xi} = \tilde{w}_{i,j,\xi}, \tag{54}$$

which replaces (6).

In this voluntary unemployment model, I keep track of population for each location and employment status, $\{L_{j,\xi}\}$, instead of labor forces $\{L_j\}$ and employment rates $\{e_j\}$ in the efficiency-wage model.

The aggregate nominal income in location j, I_j, is

$$I_j = \begin{cases} L_{j,1}\left(w_j + \frac{\pi_j}{L_j}\right) + L_{j,0}\left(b_j P_j + \frac{\pi_j}{L_j}\right) & \text{for } j \in N_{NUS}, \\ L_{j,1}\left(w_j + \frac{\pi_{US}}{L_{US}}\right) + L_{j,0}\left(b_j P_j + \frac{\pi_{US}}{L_{US}}\right) & \text{for } j \in N_{US}, \end{cases} \tag{55}$$

which replaces (14).

The aggregate expenditure in location $j \in N$ is

$$X_j = I_j + \frac{1-\beta}{\beta} w_j L_{j,1}, \tag{56}$$

which replaces (15).

As in equation (45) of the full-employment model, wages are determined by the trade balance condition or the labor market clearing condition

$$w_j L_{j,1} = \beta \frac{\sigma - 1}{\sigma} \sum_{k \in N} \left(\frac{\sigma}{\sigma - 1} \frac{w_j^{\beta} P_j^{1-\beta} t_{j,k}}{z_j P_k} \right)^{1-\sigma} X_k. \tag{57}$$

The population of the whole U.S. L_{US} and populations of non-U.S. countries $\{L_j\}_{j \in N_{NUS}}$ are given. The appeal of employment status ξ in location j is

$$\Phi_{j,\xi} = \begin{cases} \left(\frac{w_j}{P_j} + \frac{\pi_j}{L_j P_j} \right) A_j & \text{for } \xi = 1 \ \& \ j \in N_{NUS}, \\ \left(b_j + \frac{\pi_j}{L_j P_j} \right) A_j & \text{for } \xi = 0 \ \& \ j \in N_{NUS}, \\ \left(\frac{w_j}{P_j} + \frac{\pi_{US}}{L_{US} P_j} \right) A_j & \text{for } \xi = 1 \ \& \ j \in N_{US}, \\ \left(b_j + \frac{\pi_{US}}{L_{US} P_j} \right) A_j & \text{for } \xi = 0 \ \& \ j \in N_{US}. \end{cases} \tag{58}$$

Then the number of individuals of employment status ξ in location j is

$$L_{j,\xi} = \begin{cases} \frac{\Phi_{j,\xi}^{\theta}}{\sum_{\xi' \in \{0,1\}} \Phi_{j,\xi'}^{\theta}} L_j & \text{for } j \in N_{NUS} \\ \frac{\Phi_{j,\xi}^{\theta}}{\sum_{k \in N_{US}} \sum_{\xi' \in \{0,1\}} \Phi_{k,\xi'}^{\theta}} L_{US} & \text{for } j \in N_{NUS}. \end{cases} \tag{59}$$

An equilibrium is a tuple of $\{P_j\}$, $\{w_j\}$, $\{\pi_j\}$, $\{X_j\}$, $\{I_j\}$, $\{L_{j,\xi}\}$, and $\{\Phi_{j,\xi}\}$ satisfying (20), (57), (21), (56), (55), (58), (59).

An equilibrium in changes (exact hat algebra) is a tuple of $\{\hat{P}_j\}$, $\{\hat{w}_j\}$, $\{\hat{\pi}_j\}$, $\{\hat{X}_j\}$, $\{\hat{I}_j\}$, $\{\hat{L}_{j,\xi}\}$, and $\{\hat{\Phi}_{j,\xi}\}$ such that (36), (39)

$$\hat{w}_j = \left[\frac{1}{\hat{L}_{j,1}} \hat{P}_j^{(1-\beta)(1-\sigma)} \hat{z}_j^{\sigma-1} \sum_k (\alpha_{j,k} \hat{t}_{j,k}^{1-\sigma}) \hat{X}_k \right]^{\frac{1}{1-\beta(1-\sigma)}}, \tag{60}$$

$$\hat{X}_j = \frac{I_j' + \frac{1-\beta}{\beta} w_j \hat{w}_j L_{j,1} \hat{L}_{j,1}}{I_j + \frac{1-\beta}{\beta} w_j L_{j,1}}, \tag{61}$$

$$I_j' = \begin{cases} L_{j,1} \hat{L}_{j,1} w_j \hat{w}_j + L_{j,0} \hat{L}_{j,0} b_j P_j \hat{P}_j + \pi_j \hat{\pi}_j & \text{for } j \in N_{NUS}, \\ L_{j,1} \hat{L}_{j,1} w_j \hat{w}_j + L_{j,0} \hat{L}_{j,0} b_j P_j \hat{P}_j + L_j \hat{L}_j \pi_{US} \hat{\pi}_{US} / L_{US} & \text{for } j \in N_{US}, \end{cases} \tag{62}$$

$$\hat{L}_{j,\xi} = \hat{\mu}_{j,\xi} = \begin{cases} \frac{\hat{\Phi}^{\theta}_{j,\xi}}{\sum_{\xi' \in \{0,1\}} \mu_{j,\xi'} \hat{\Phi}^{\theta}_{j,\xi'}} & \text{for } j \in N_{NUS}, \\ \frac{\hat{\Phi}^{\theta}_{j,\xi}}{\sum_{k \in N_{US}} \sum_{\xi' \in \{0,1\}} \mu_{k,\xi'} \hat{\Phi}^{\theta}_{k,\xi'}} & \text{for } j \in N_{NUS}, \end{cases} \tag{63}$$

where $\mu_{j,\xi} = L_{j,\xi}/L_j$ for $j \in N_{NUS}$ and $\mu_{j,\xi} = L_{j,\xi}/L_{US}$ for $j \in N_{US}$, and

$$\Phi_{j,\xi} = \begin{cases} \frac{1}{\hat{P}_j} \frac{w_j \hat{w}_j + \frac{\pi_j \hat{\pi}_j}{L_j}}{w_j + \frac{\pi_j}{L_j}} & \text{for } j \in N_{NUS} \ \& \ \xi = 1, \\ \frac{b_j P_j + \frac{\pi_j \hat{\pi}_j}{L_j \hat{P}_j}}{b_j P_j + \frac{\pi_j}{L_j}} & \text{for } j \in N_{NUS} \ \& \ \xi = 0, \\ \frac{1}{\hat{P}_j} \frac{w_j \hat{w}_j + \frac{\pi_{US} \hat{\pi}_{US}}{L_{US}}}{w_j + \frac{\pi_{US}}{L_{US}}} & \text{for } j \in N_{US} \ \& \ \xi = 1, \\ \frac{b_j P_j + \frac{\pi_j \hat{\pi}_{US}}{L_{US} \hat{P}_j}}{b_j P_j + \frac{\pi_{US}}{L_{US}}} & \text{for } j \in N_{US} \ \& \ \xi = 0. \end{cases} \tag{64}$$

D Quantification of the Alternative Models

D.1 Full-Employment Model

Since the full-employment model does not allow unemployment, L_j in the baseline equilibrium is calibrated to be the employment in location j. Calibration of the other variables and parameters follow the calibration of the efficiency-wage model in Section 3.

D.2 Voluntary-Unemployment Model

For the sake of apple-to-apple comparison with quantitative results of the efficiency-wage model, unemployment rates in this voluntary-unemployment model are calibrated to involuntary unempyloment rates detailed in Section 3. This is different from nonemployment in Caliendo et al. (2019); they calibrated baseline nonemployment to be involuntary unemployment plus voluntary nonemployment. I opt to set baseline unemployment equal to only involuntary unemployment because in my main efficiency-wage model, unemployment is clearly involuntary unemployment, and to compare results between the efficiency-wage model and the voluntary-unemployment model, voluntary nonemployment should not suddenly show up in the voluntary-unemployment model.

Another caveat is that following Caliendo et al. (2019), the elasticity of labor force L_j with respect to appeal $\Phi_{j,\xi}$, θ, is common across locations and employment statuses (See (59)). As in Section 3, this elasticity θ is set to be 1.5, following Tombe and Zhu (2019).

E Additional Coutnerfactual Results

E.1 Efficiency-Wage Model

Table 4: The US Welfare Changes from a 3% Increase in China's Productivity for Three Values of η

η	1.01	1.03	1.05	1.07	1.10
% Change in the US Welfare	0.087	0.087	0.087	0.087	0.087

Figure 8: % Changes in Real Wages in the US States in Response to a 3% Increase in China's Productivity: the Efficiency-Wage Model with the Import Intensity of California across U.S. States

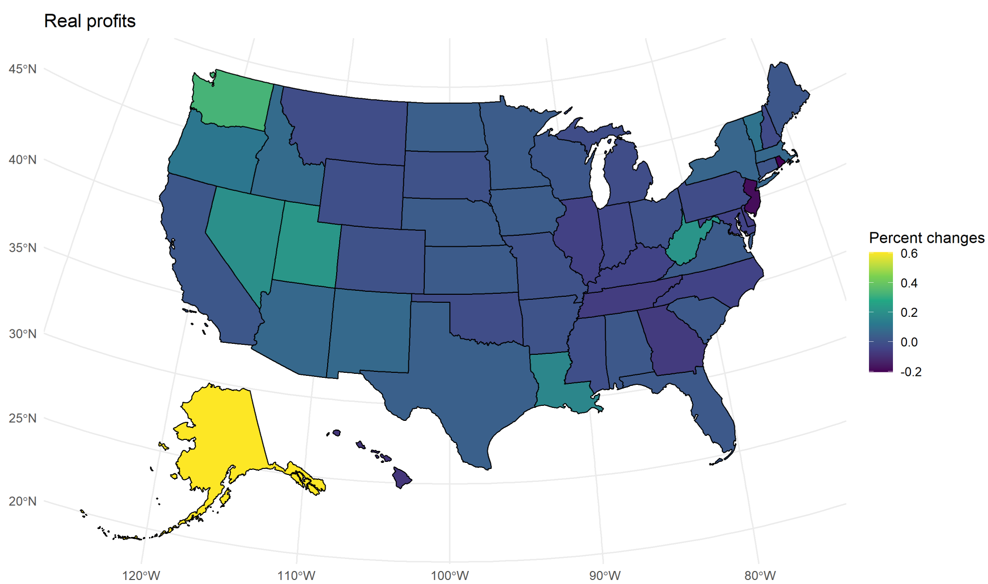

Figure 9: % Changes in Real Profits in the US States in Response to a 3% Increase in China's Productivity: the Efficiency-Wage Model with the Import Intensity of California across U.S. States

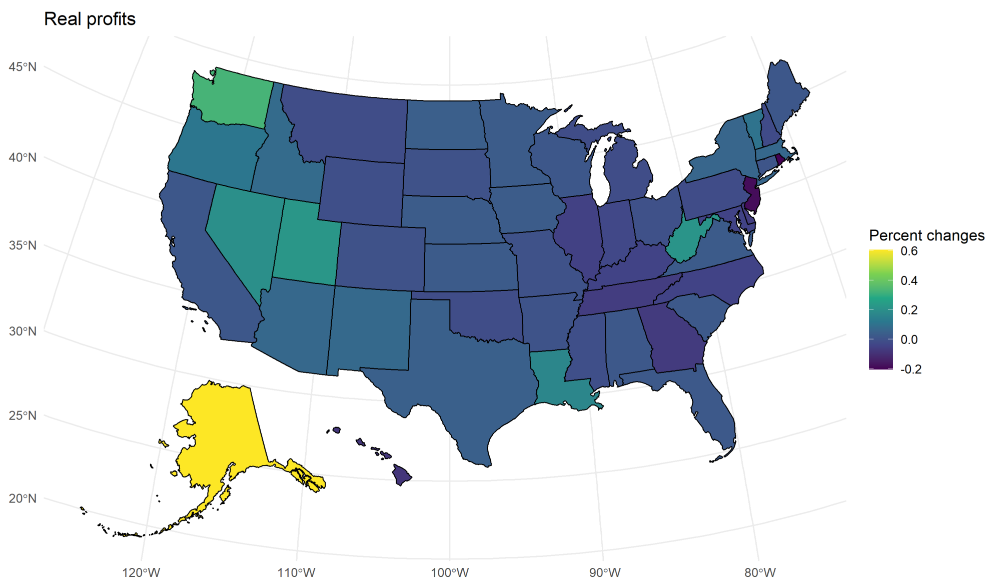

Figure 10: Percentage Point Changes in Unemployment in the US States in Response to a 3% Increase in China's Productivity: the Efficiency-Wage Model with the Import Intensity of California across U.S. States

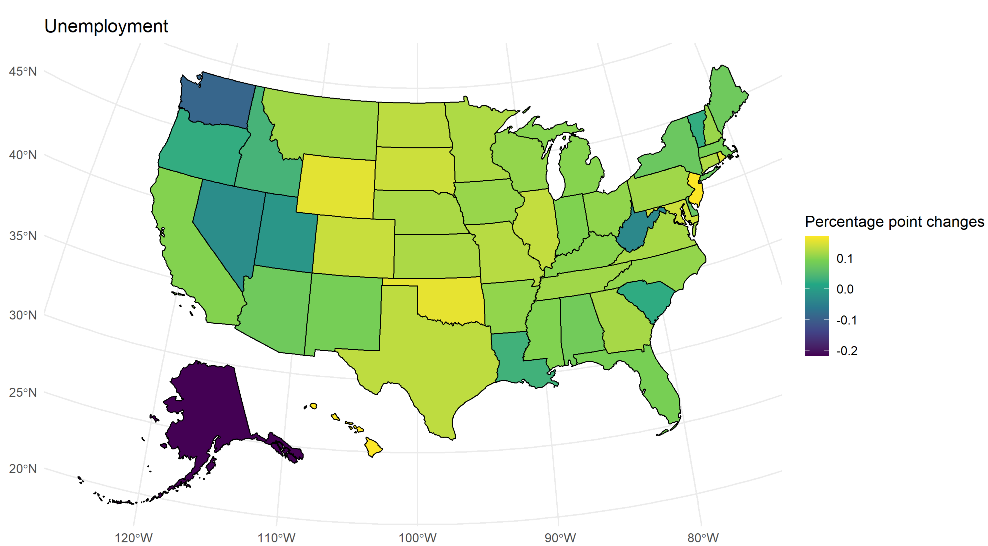

Figure 11: % Changes in Labor Forces in the US States in Response to a 3% Increase in China's Productivity: the Efficiency-Wage Model with the Import Share of California across U.S. States

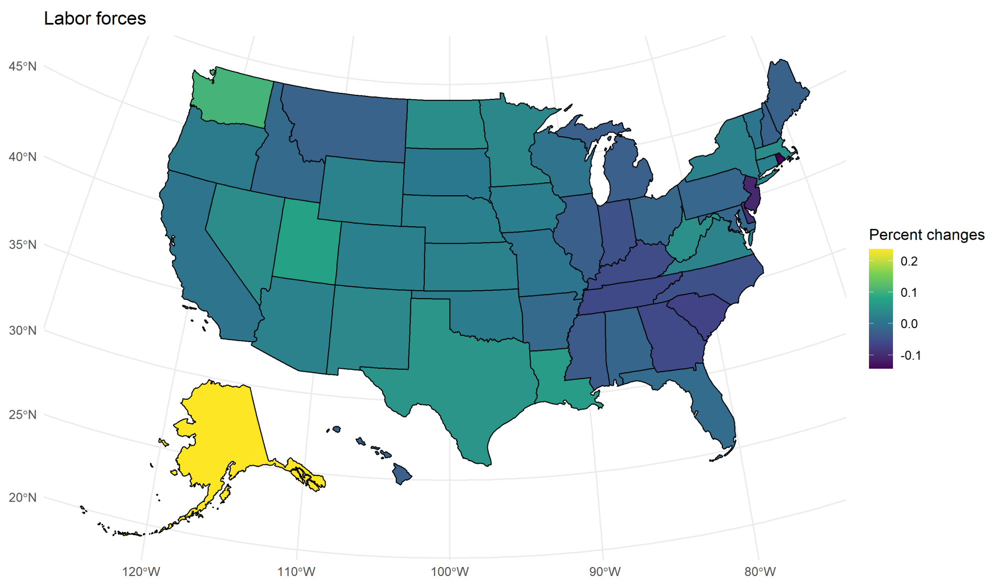

Figure 12: % Changes in Real Wages in the US States in Response to a 3% Increase in China's Productivity: the Efficiency-Wage Model with the Export Intensity of Alaska across U.S. States

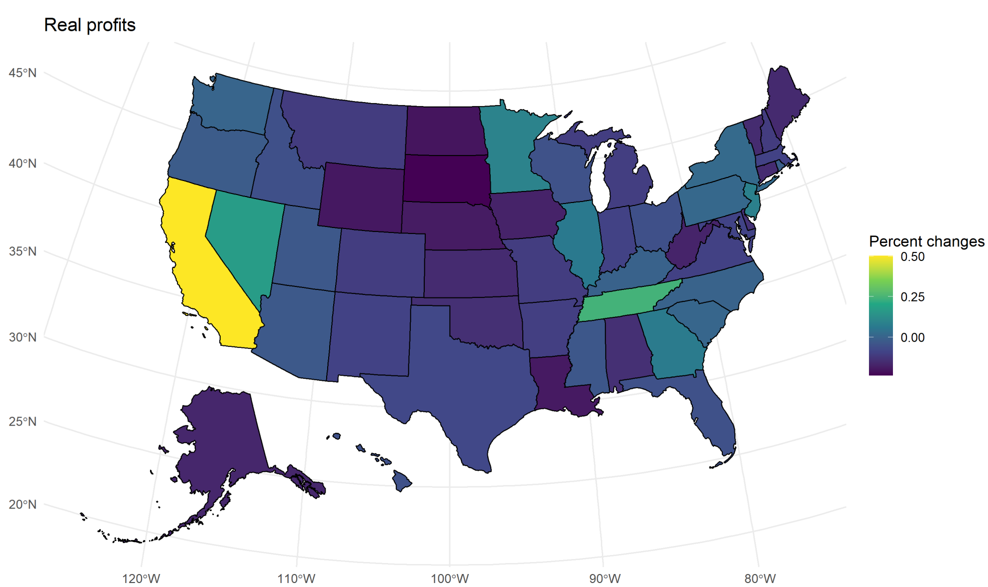

Figure 13: % Changes in Real Profits in the US States in Response to a 3% Increase in China's Productivity: the Efficiency-Wage Model with the Export Intensity of Alaska across U.S. States

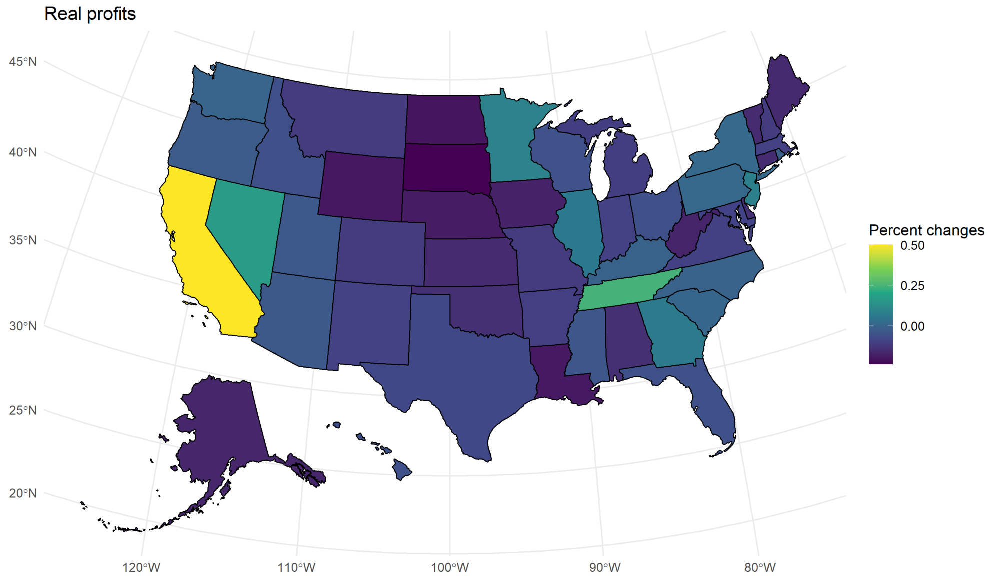

Figure 14: Percentage Point Changes in Unemployment in the US States in Response to a 3% Increase in China's Productivity: the Efficiency-Wage Model with the Export Intensity of Alaska across U.S. States

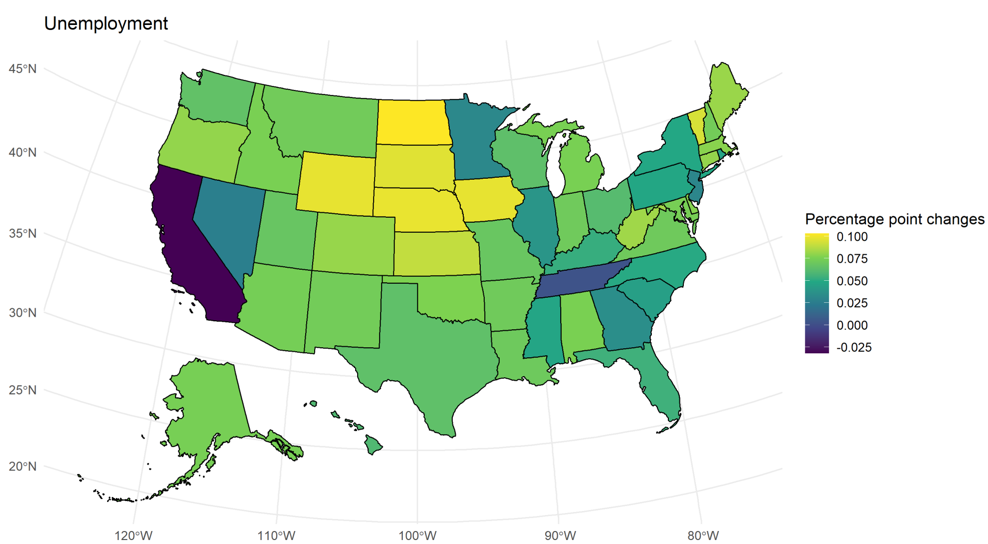

Figure 15: % Changes in Labor Forces in the US States in Response to a 3% Increase in China's Productivity: the Efficiency-Wage Model with the Export Intensity of Alaska across U.S. States

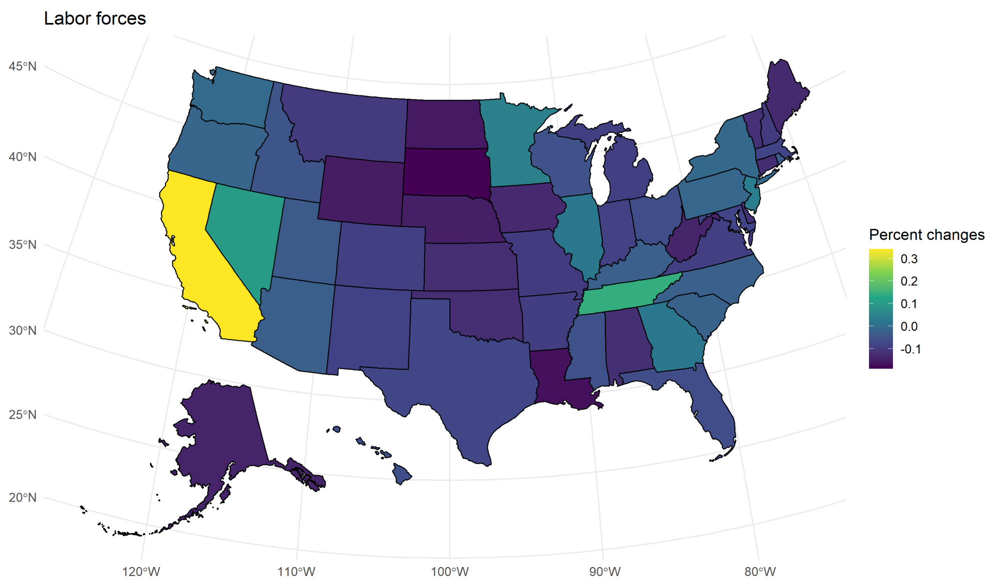

Figure 16: % Changes in Real Wages in the US States in Response to a 3% Increase in China's Productivity: the Efficiency-Wage Model with the Unemployment Rate of Nevada across U.S. States

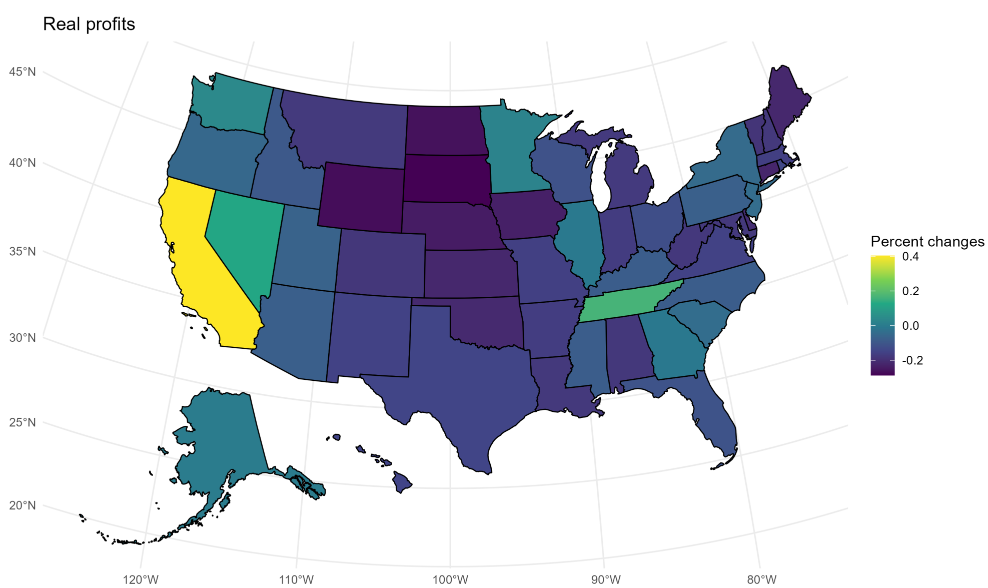

Figure 17: % Changes in Real Profits in the US States in Response to a 3% Increase in China's Productivity: the Efficiency-Wage Model with the Unemployment Rate of Nevada across U.S. States

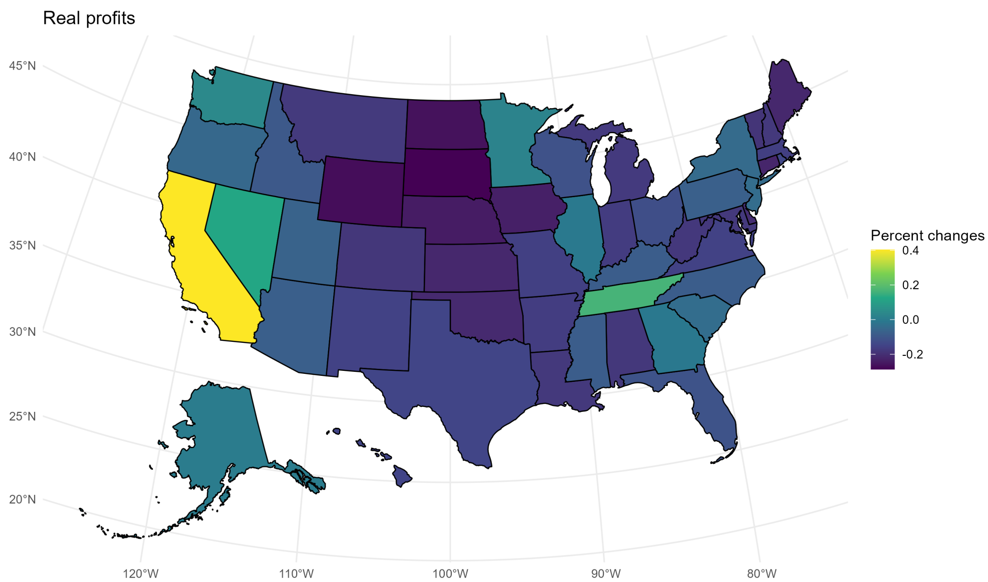

Figure 18: Percentage Point Changes in Unemployment in the US States in Response to a 3% Increase in China's Productivity: the Efficiency-Wage Model with the Unemployment Rate of Nevada across U.S. States

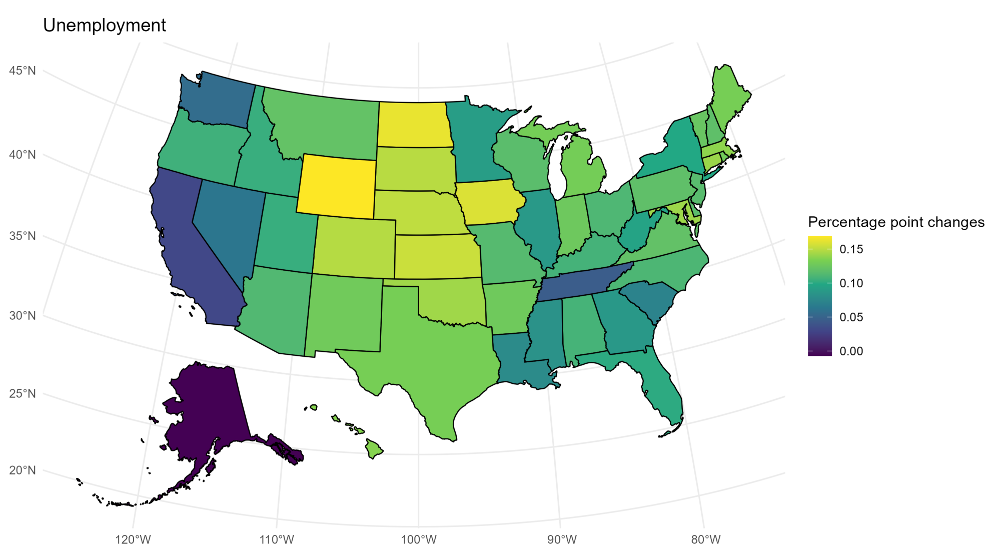

Figure 19: % Changes in Labor Forces in the US States in Response to a 3% Increase in China's Productivity: the Efficiency-Wage Model with the Unemployment Rate of Nevada across U.S. States

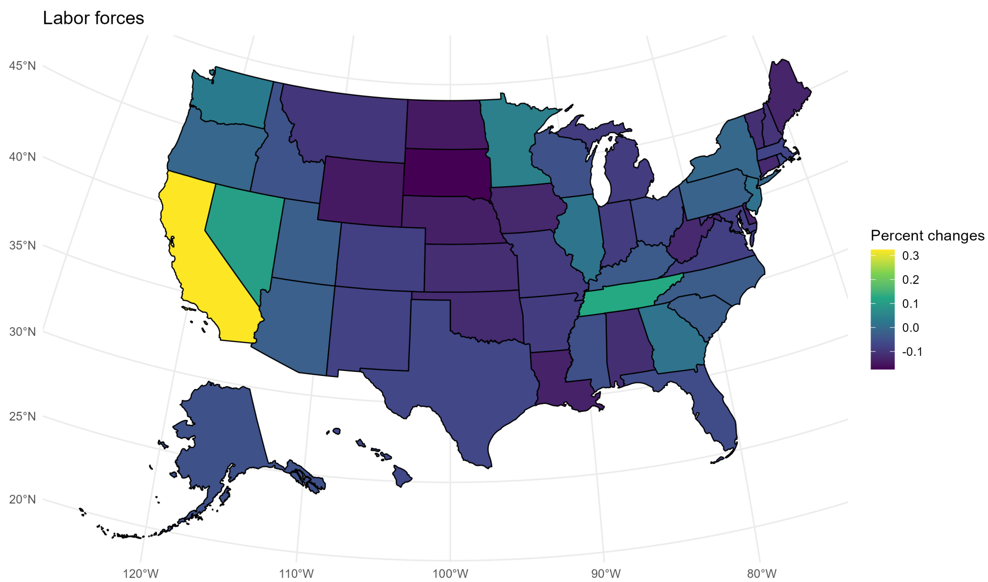

Table 5: Changes in Equilibrium Outcomes of Countries in Response to a 3% Increase in China's Productivity: the Efficiency-Wage Model with $\eta = 1.05$ and the Import Intensity of California across U.S. States

Country	Real Wage %	Real Profits %	Unemployment p.p.	Walfare %
Australia	0.08	-0.02	0.09	0.00
Belgium	0.07	-0.07	0.13	-0.02
Canada	0.06	-0.05	0.10	-0.03
China	4.42	8.07	-3.35	7.46
Czech Republic	0.11	0.06	0.05	0.07
Denmark	0.06	-0.14	0.18	-0.05
Estonia	0.08	-0.00	0.07	0.02
Finland	0.06	-0.10	0.15	-0.04
France	0.06	-0.13	0.18	-0.05
Germany	0.07	-0.06	0.12	-0.01
Greece	0.04	-0.08	0.09	-0.06
Hungary	0.04	-0.06	0.09	-0.05
Ireland	0.06	-0.08	0.12	-0.04
Israel	0.05	-0.05	0.10	-0.04
Italy	0.04	-0.04	0.07	-0.04
Japan	0.07	-0.03	0.10	0.00
Korea, South	0.14	0.09	0.05	0.10
Netherlands	0.08	0.01	0.07	0.05
New Zealand	0.08	-0.01	0.09	0.01
Norway	0.06	-0.16	0.20	-0.06
Poland	0.07	-0.05	0.10	-0.01
Slovakia	0.09	0.01	0.07	0.02
Slovenia	0.06	-0.05	0.10	-0.03
Spain	0.06	-0.14	0.15	-0.05
Sweden	0.04	-0.12	0.15	-0.07
Switzerland	0.07	-0.16	0.22	-0.04
United Kingdom	0.05	-0.09	0.13	-0.05
United States				0.09

Table 6: Changes in Equilibrium Outcomes of Countries in Response to a 3% Increase in China's Productivity: the Efficiency-Wage Model with $\eta = 1.05$ and the Export Intensity of Alaska across U.S. States

Country	Real Wage %	Real Profits %	Unemployment p.p.	Walfare %
Australia	0.08	-0.02	0.09	0.00
Belgium	0.07	-0.07	0.13	-0.02
Canada	0.06	-0.05	0.10	-0.03
China	4.42	8.07	-3.35	7.46
Czech Republic	0.11	0.06	0.05	0.07
Denmark	0.06	-0.14	0.18	-0.05
Estonia	0.08	-0.00	0.07	0.02
Finland	0.06	-0.10	0.15	-0.04
France	0.06	-0.13	0.18	-0.05
Germany	0.07	-0.06	0.12	-0.01
Greece	0.04	-0.08	0.09	-0.06
Hungary	0.04	-0.06	0.09	-0.05
Ireland	0.06	-0.08	0.12	-0.04
Israel	0.05	-0.05	0.10	-0.04
Italy	0.04	-0.04	0.07	-0.04
Japan	0.07	-0.03	0.10	0.00
Korea, South	0.14	0.09	0.05	0.10
Netherlands	0.08	0.01	0.07	0.05
New Zealand	0.08	-0.01	0.09	0.01
Norway	0.06	-0.16	0.20	-0.06
Poland	0.07	-0.05	0.10	-0.01
Slovakia	0.09	0.01	0.07	0.02
Slovenia	0.06	-0.05	0.10	-0.03
Spain	0.06	-0.14	0.15	-0.05
Sweden	0.04	-0.12	0.15	-0.07
Switzerland	0.07	-0.16	0.22	-0.04
United Kingdom	0.05	-0.09	0.13	-0.05
United States				0.09

Table 7: Changes in Equilibrium Outcomes of Countries in Response to a 3% Increase in China's Productivity: the Efficiency-Wage Model with $\eta = 1.05$ and the Unemployment Rate of Nevada across U.S. States

Country	Real Wage %	Real Profits %	Unemployment p.p.	Walfare %
Australia	0.08	-0.02	0.09	0.00
Belgium	0.07	-0.07	0.13	-0.02
Canada	0.06	-0.05	0.10	-0.03
China	4.42	8.07	-3.35	7.46
Czech Republic	0.11	0.06	0.05	0.07
Denmark	0.06	-0.14	0.18	-0.05
Estonia	0.08	-0.00	0.07	0.02
Finland	0.06	-0.10	0.15	-0.04
France	0.06	-0.13	0.18	-0.05
Germany	0.07	-0.06	0.12	-0.01
Greece	0.04	-0.08	0.09	-0.06
Hungary	0.04	-0.06	0.09	-0.05
Ireland	0.06	-0.08	0.12	-0.04
Israel	0.05	-0.05	0.10	-0.04
Italy	0.04	-0.04	0.07	-0.04
Japan	0.07	-0.03	0.10	0.00
Korea, South	0.14	0.09	0.05	0.10
Netherlands	0.08	0.01	0.07	0.05
New Zealand	0.08	-0.01	0.09	0.01
Norway	0.06	-0.16	0.20	-0.06
Poland	0.07	-0.05	0.10	-0.01
Slovakia	0.09	0.01	0.07	0.02
Slovenia	0.06	-0.05	0.10	-0.03
Spain	0.06	-0.14	0.15	-0.05
Sweden	0.04	-0.12	0.15	-0.07
Switzerland	0.07	-0.16	0.22	-0.04
United Kingdom	0.05	-0.09	0.13	-0.05
United States				0.09

E.2 Voluntary-Unemployment Model

Figure 20: % Changes in Real Wages in the US States in Response to a 3% Increase in China's Productivity: the Voluntary-Unemployment Model

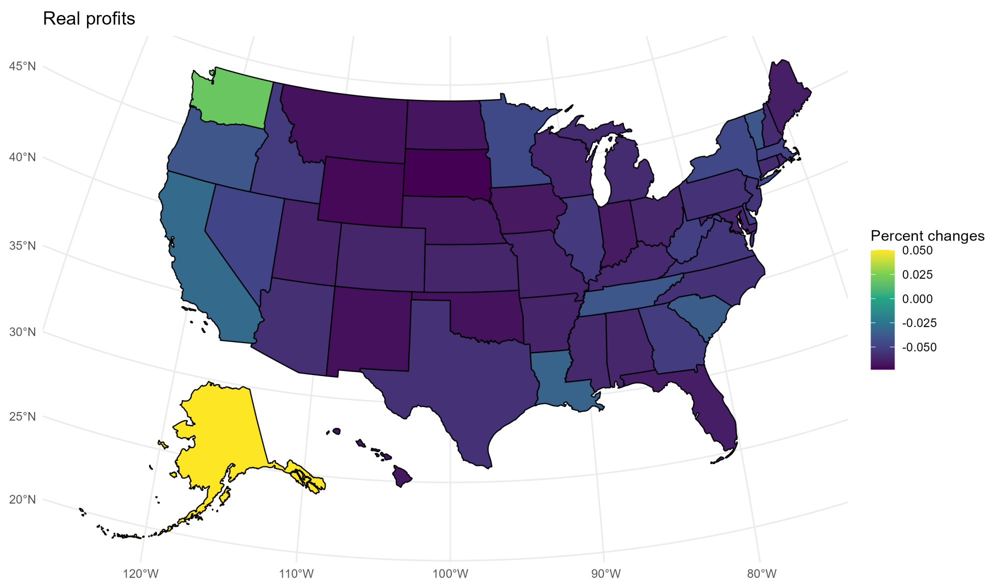

Figure 21: % Changes in Real Profits in the US States in Response to a 3% Increase in China's Productivity: the Voluntary-Unemployment Model

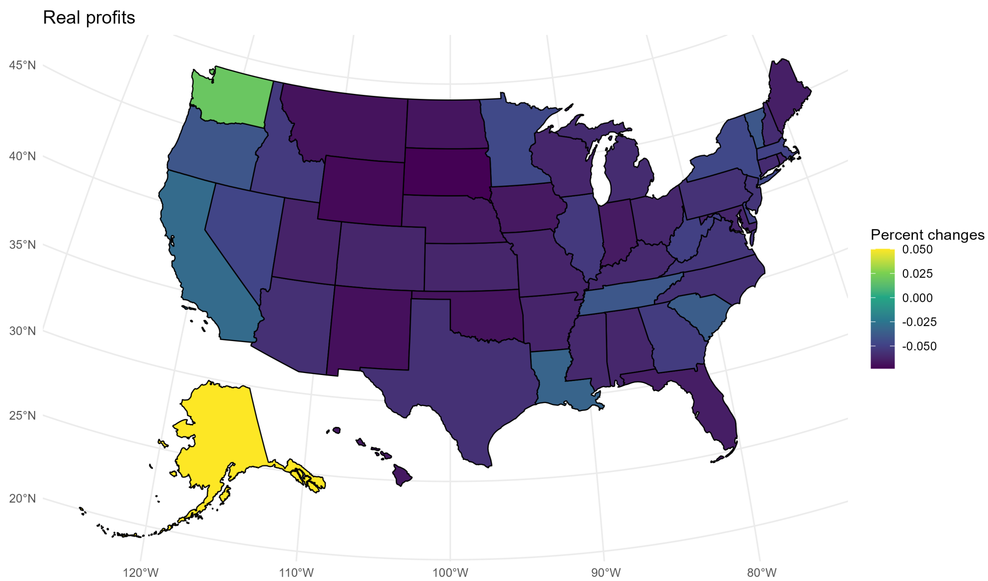

Figure 22: Percentage Point Changes in Unemployment in the US States in Response to a 3% Increase in China's Productivity the Voluntary-Unemployment Model

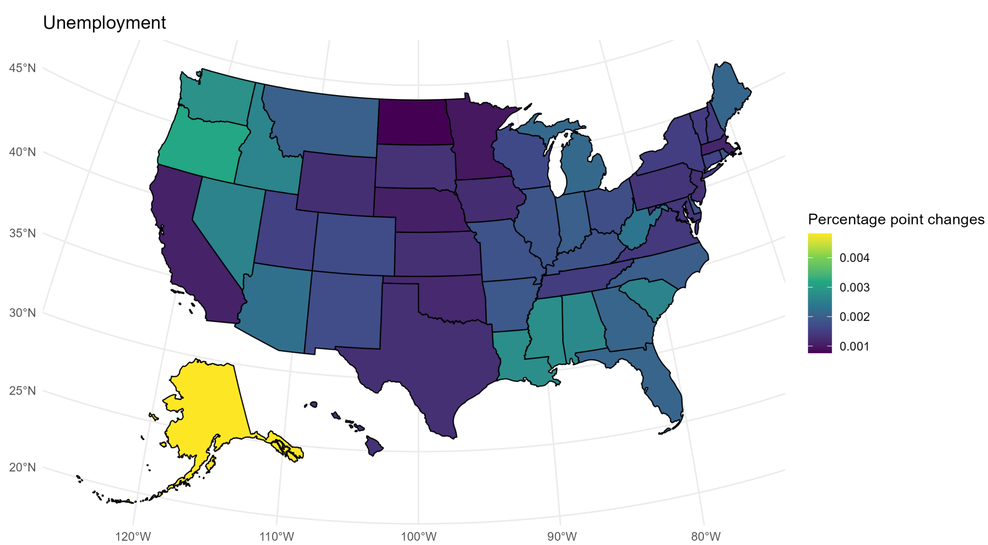

Figure 23: % Changes in Labor Forces in the US States in Response to a 3% Increase in China's Productivity the Voluntary-Unemployment Model

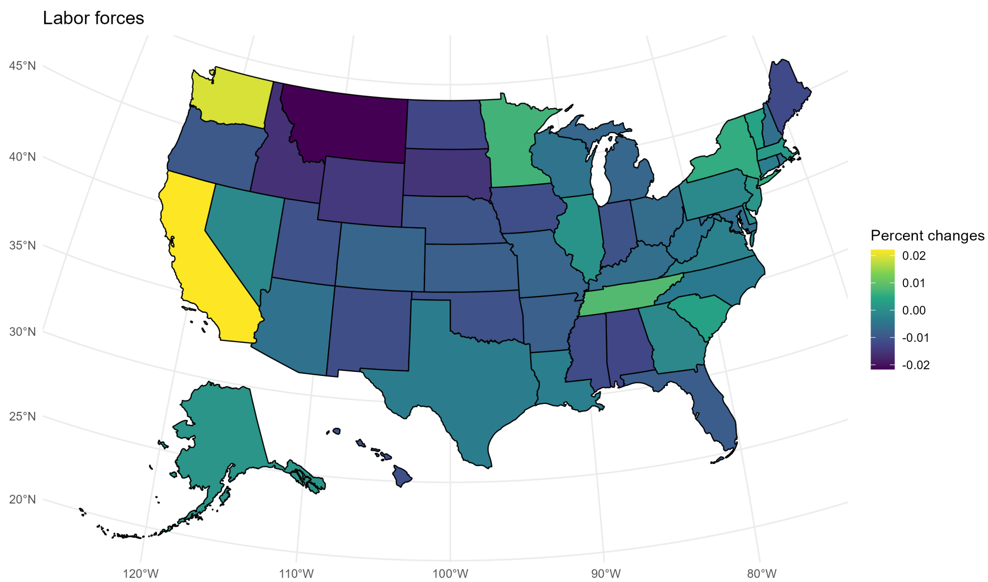

Table 8: Changes in Equilibrium Outcomes of Countries in Response to a 3% Increase in China's Productivity: the Voluntary-Unemployment Model

Country	Real Wage %	Real Profits %	Unemployment p.p.	Walfare %
Australia	0.02	0.10	-0.00	0.04
Belgium	0.01	-0.04	0.00	-0.01
Canada	0.01	-0.04	0.00	-0.01
China	4.62	4.11	0.10	4.40
Czech Republic	0.01	-0.04	0.00	-0.02
Denmark	0.00	-0.05	0.00	-0.01
Estonia	0.01	-0.06	0.00	-0.02
Finland	0.01	-0.03	0.00	-0.01
France	0.00	-0.05	0.00	-0.02
Germany	0.01	-0.01	0.00	0.00
Greece	-0.00	-0.07	0.01	-0.03
Hungary	-0.00	-0.07	0.00	-0.05
Ireland	0.01	-0.03	0.00	-0.00
Israel	0.01	-0.03	0.00	-0.01
Italy	0.00	-0.05	0.00	-0.02
Japan	0.01	0.02	0.00	0.02
Korea, South	0.06	0.21	-0.00	0.11
Netherlands	0.01	-0.04	0.00	-0.01
New Zealand	0.01	0.03	-0.00	0.02
Norway	0.00	-0.05	0.00	-0.02
Poland	0.00	-0.06	0.00	-0.02
Slovakia	0.01	-0.02	0.00	-0.00
Slovenia	0.00	-0.05	0.00	-0.02
Spain	0.00	-0.06	0.00	-0.02
Sweden	0.00	-0.04	0.00	-0.01
Switzerland	0.01	0.00	0.00	0.01
United Kingdom	0.00	-0.05	0.00	-0.02
United States				-0.01

E.3 Large Shocks

I consider two large shocks: a 10% increase and a 62& decrease in China's productivity in the efficiency-wage model. As I admit in Section 2, for such large shocks, employment rates may not lie between 0 and 1. For brevity, I show tables instead of maps for U.S. states.

Tables 9 and 10 report the results for a 10% increase in China's productivity. In Table 10, welfare changes are nationwide U.S. welfare changes, therefore, all states have the same value. The tables show that the geographic pattern of effects is similar to that observed for the 3% increase discussed in the main text. For example, unemployment decreases only in Alaska, while California experiences a relatively small increase in unemployment. The unemployment rate declines by 10.4 percentage points, even though the baseline unemployment rate in 2012 is only 4.1%.

Using their model together with an Autor–Dorn–Hanson–style regression, Caliendo et al. (2019) estimate a quarterly TFP growth rate of 3% in China's computer and electronics sector from 2000 to 2007 (see their Table 15).[28] This implies that TFP in that sector increased by approximately 158% over the period ($((1.03)^4)^8 \approx 2.58$). Although this growth pertains to a single industry, I next consider a counterfactual in which China's productivity decreases by 62% to offset this increase ($1/((1.03)^4)^8 \approx 0.38$). I do so because Caliendo et al. (2019) also examine a hypothetical decline in China's productivity to illustrate a no–China-shock scenario. Tables 11 and 12 report the results. Again, in Table 12, welfare changes are nationwide. U.S. welfare increases by 7.9%, driven entirely by large increases in real profits, as real wages fall in all states and unemployment rises in most states. The model predicts an increase in China's unemployment rate of 90 percentage points, which is implausible.

[28]The 3% growth rate is not at the high end of the estimates reported in their table.

Table 9: Changes in Equilibrium Outcomes of Countries in Response to a 10% Increase in China's Productivity: the Efficiency-Wage Model

Country	Real Wage %	Real Profits %	Unemployment p.p.	Welfare %
Australia	0.25	-0.03	0.26	0.03
Belgium	0.22	-0.20	0.39	-0.04
Canada	0.18	-0.15	0.30	-0.09
China	15.05	27.47	-10.35	25.53
Czech Republic	0.35	0.20	0.14	0.23
Denmark	0.19	-0.41	0.56	-0.14
Estonia	0.26	0.01	0.23	0.07
Finland	0.19	-0.30	0.46	-0.11
France	0.19	-0.40	0.54	-0.14
Germany	0.23	-0.16	0.37	-0.01
Greece	0.13	-0.24	0.28	-0.17
Hungary	0.12	-0.18	0.27	-0.15
Ireland	0.19	-0.24	0.36	-0.10
Israel	0.17	-0.15	0.30	-0.10
Italy	0.13	-0.13	0.23	-0.13
Japan	0.24	-0.08	0.30	0.02
Korea, South	0.46	0.32	0.14	0.33
Netherlands	0.27	0.07	0.19	0.16
New Zealand	0.25	-0.03	0.26	0.04
Norway	0.18	-0.47	0.63	-0.19
Poland	0.21	-0.13	0.31	-0.03
Slovakia	0.28	0.04	0.21	0.06
Slovenia	0.19	-0.16	0.32	-0.07
Spain	0.18	-0.42	0.45	-0.17
Sweden	0.14	-0.38	0.48	-0.22
Switzerland	0.21	-0.48	0.65	-0.11
United Kingdom	0.17	-0.27	0.40	-0.15

Table 10: Changes in Equilibrium Outcomes of Countries in Response to a 10% Increase in China's Productivity: the Efficiency-Wage Model

State	Real Wage %	Real Profits &	Unemployment p.p.	Labor Force %	Welfare %
Alabama	0.16	-0.56	0.33	-0.36	0.31
Alaska	0.14	0.09	-0.08	-0.13	0.31
Arizona	0.21	-0.23	0.35	-0.07	0.31
Arkansas	0.19	-0.51	0.39	-0.28	0.31
California	0.36	1.29	0.08	1.02	0.31
Colorado	0.20	-0.57	0.46	-0.27	0.31
Connecticut	0.17	-0.70	0.44	-0.39	0.31
Delaware	0.16	-0.63	0.36	-0.40	0.31
Florida	0.19	-0.35	0.31	-0.20	0.31
Georgia	0.23	-0.02	0.27	0.04	0.31
Hawaii	0.20	-0.46	0.42	-0.21	0.31
Idaho	0.20	-0.28	0.31	-0.14	0.31
Illinois	0.22	-0.02	0.27	0.05	0.31
Indiana	0.19	-0.53	0.39	-0.29	0.31
Iowa	0.18	-0.73	0.49	-0.39	0.31
Kansas	0.19	-0.68	0.48	-0.36	0.31
Kentucky	0.21	-0.25	0.33	-0.11	0.31
Louisiana	0.13	-0.53	0.23	-0.42	0.31
Maine	0.17	-0.68	0.40	-0.41	0.31
Maryland	0.19	-0.55	0.44	-0.27	0.31
Massachusetts	0.20	-0.49	0.43	-0.23	0.31
Michigan	0.19	-0.54	0.40	-0.29	0.31
Minnesota	0.24	0.09	0.28	0.15	0.31
Mississippi	0.19	-0.25	0.25	-0.17	0.31
Missouri	0.17	-0.50	0.36	-0.29	0.31
Montana	0.18	-0.54	0.38	-0.32	0.31
Nebraska	0.16	-0.76	0.47	-0.43	0.31
Nevada	0.27	0.40	0.18	0.33	0.31
New Hampshire	0.17	-0.55	0.37	-0.33	0.31
New Jersey	0.23	-0.12	0.35	0.04	0.31
New Mexico	0.19	-0.48	0.40	-0.25	0.31
New York	0.22	-0.13	0.30	-0.02	0.31
North Carolina	0.22	-0.25	0.34	-0.09	0.31
North Dakota	0.16	-0.83	0.51	-0.46	0.31
Ohio	0.19	-0.38	0.35	-0.20	0.31
Oklahoma	0.18	-0.67	0.45	-0.38	0.31
Oregon	0.22	-0.14	0.31	-0.02	0.31
Pennsylvania	0.22	-0.23	0.37	-0.05	0.31
Rhode Island	0.21	-0.43	0.39	-0.20	0.31
South Carolina	0.21	-0.11	0.21	-0.08	0.31
South Dakota	0.14	-0.90	0.47	-0.56	0.31
Tennessee	0.28	0.54	0.14	0.41	0.31
Texas	0.20	-0.45	0.41	-0.21	0.31
Utah	0.22	-0.20	0.32	-0.07	0.31
Vermont	0.18	-0.57	0.37	-0.35	0.31
Virginia	0.18	-0.47	0.38	-0.26	0.31
Washington	0.23	0.19	0.14	0.11	0.31
West Virginia	0.15	-0.55	0.29	-0.39	0.31
Wisconsin	0.20	-0.35	0.36	-0.16	0.31
Wyoming	0.17	-0.85	0.53	-0.47	0.31

Table 11: Changes in Equilibrium Outcomes of Countries in Response to a 62% Decrease in China's Productivity: the Efficiency-Wage Model

Country	Real Wage %	Real Profits %	Unemployment p.p.	Welfare %
Australia	-0.39	5.49	-5.59	4.18
Belgium	-1.29	7.19	-7.95	3.82
Canada	-0.95	3.58	-4.24	2.75
China	-53.54	-97.20	90.12	-82.81
Czech Republic	-2.07	1.62	-3.51	0.78
Denmark	-1.38	8.90	-9.64	4.07
Estonia	-1.70	3.08	-4.37	1.75
Finland	-1.13	7.81	-8.34	4.19
France	-1.42	8.74	-9.29	4.04
Germany	-1.09	8.61	-9.29	4.53
Greece	-1.10	3.33	-3.38	2.46
Hungary	-0.72	2.81	-3.17	2.47
Ireland	-0.65	7.30	-6.76	4.64
Israel	-0.71	3.61	-4.05	2.97
Italy	-0.54	2.31	-2.56	2.25
Japan	-1.17	5.45	-6.40	3.29
Korea, South	-0.33	3.93	-4.13	3.38
Netherlands	-2.03	5.92	-7.65	1.97
New Zealand	-0.96	4.89	-5.52	3.35
Norway	-1.24	9.16	-10.18	4.55
Poland	-1.53	3.85	-4.91	2.21
Slovakia	-1.39	2.13	-3.08	1.68
Slovenia	-1.30	3.67	-4.59	2.42
Spain	-1.37	7.73	-6.94	3.68
Sweden	-0.69	6.82	-6.96	4.41
Switzerland	-1.25	15.13	-15.84	6.18
United Kingdom	-1.08	5.01	-5.66	3.24

Table 12: Changes in Equilibrium Outcomes of Countries in Response to a 62% Decrease in China's Productivity: the Efficiency-Wage Model

State	Real Wage %	Real Profits &	Unemployment p.p.	Labor Force %	Welfare %
Alabama	-1.00	6.57	1.57	-5.51	7.93
Alaska	-0.77	24.67	8.78	-14.35	7.93
Arizona	-1.30	5.13	0.36	-5.64	7.93
Arkansas	-1.32	6.85	1.27	-6.40	7.93
California	-2.57	-4.40	-6.74	-4.67	7.93
Colorado	-1.42	7.23	1.73	-6.37	7.93
Connecticut	-1.16	7.98	3.18	-5.39	7.93
Delaware	-0.90	9.47	3.75	-6.00	7.93
Florida	-1.16	3.70	0.32	-4.19	7.93
Georgia	-1.57	3.31	-0.81	-5.28	7.93
Hawaii	-1.49	6.29	1.03	-6.39	7.93
Idaho	-1.31	7.42	0.70	-7.52	7.93
Illinois	-1.37	2.12	-0.78	-3.98	7.93
Indiana	-1.31	5.73	0.93	-5.63	7.93
Iowa	-1.32	8.16	2.12	-6.96	7.93
Kansas	-1.38	8.50	2.19	-7.24	7.93
Kentucky	-1.46	4.12	-0.25	-5.46	7.93
Louisiana	-0.67	11.79	4.30	-7.34	7.93
Maine	-1.14	8.06	2.22	-6.40	7.93
Maryland	-1.39	6.96	1.95	-5.94	7.93
Massachusetts	-1.47	8.60	2.70	-6.83	7.93
Michigan	-1.39	6.71	1.30	-6.20	7.93
Minnesota	-1.67	3.51	-0.65	-5.61	7.93
Mississippi	-1.07	4.07	0.06	-4.68	7.93
Missouri	-0.97	5.63	1.44	-4.79	7.93
Montana	-1.10	6.39	1.30	-5.82	7.93
Nebraska	-1.03	8.14	2.54	-6.29	7.93
Nevada	-1.89	1.34	-2.75	-5.53	7.93
New Hampshire	-0.98	6.93	2.34	-5.21	7.93
New Jersey	-1.82	4.00	-0.36	-5.71	7.93
New Mexico	-1.28	5.60	1.03	-5.46	7.93
New York	-1.44	5.15	0.98	-5.16	7.93
North Carolina	-1.55	5.32	0.17	-6.17	7.93
North Dakota	-1.11	8.18	2.91	-6.10	7.93
Ohio	-1.24	4.85	0.72	-5.01	7.93
Oklahoma	-1.18	6.71	1.97	-5.60	7.93
Oregon	-1.57	8.97	0.88	-8.87	7.93
Pennsylvania	-1.70	5.17	0.16	-6.28	7.93
Rhode Island	-1.59	6.32	0.97	-6.26	7.93
South Carolina	-1.34	7.04	0.79	-6.93	7.93
South Dakota	-0.81	7.60	2.67	-5.40	7.93
Tennessee	-1.72	-1.15	-3.25	-3.65	7.93
Texas	-1.45	7.01	1.76	-6.26	7.93
Utah	-1.47	4.94	0.15	-5.98	7.93
Vermont	-1.21	11.46	3.26	-8.79	7.93
Virginia	-1.15	6.93	2.13	-5.57	7.93
Washington	-1.72	15.83	3.21	-13.02	7.93
West Virginia	-0.85	8.62	2.66	-6.22	7.93
Wisconsin	-1.33	5.08	0.53	-5.51	7.93
Wyoming	-1.25	8.06	2.57	-6.32	7.93