International Competition and Labor Market Adjustment

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Abstract

How does welfare change in the short- and long-run when trade integration takes place under imperfect labor markets? Even if consumers benefit from lower prices, there can be significant welfare losses from increases in unemployment and lower wages. I construct a dynamic multi-sector-country Ricardian trade model that incorporates both search frictions and labor mobility frictions. I then structurally estimate this model and quantify both the potential losses to workers and benefits to consumers arising from China's integration into the global economy. I find that overall welfare increases in all economies, both in the transition period and in the new steady state equilibrium. In import competing sectors, however, workers bear a costly transition, experiencing lower wages and a rise in unemployment. I also conduct an exercise with model-based simulated worker level data for the UK and the USA. I find that Chinese import competition reduces relative workers' earnings, and the magnitudes of the effects are similar to the ones found in the trade-labor reduced form literature.

Keywords: Trade, unemployment, earnings, China.

JEL: F16, J62, J64

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1 Introduction

It has been recognized that trade openness is likely to be welfare improving in the long-run, by decreasing prices and allowing countries to expand their production to new markets. These gains, however, generally neglect important labor market aspects that take place during the adjustment process, such as displacement of workers in sectors harmed by import competition and the fact that workers do not move immediately to growing exporting sectors.

The first contribution of this paper is to provide a tractable framework to structurally quantify the impact of trade shocks in a world with both search frictions and labor mobility frictions between sectors. I calculate changes in welfare arising from the emergence of China, both in the new equilibrium and along the transition period. My calculations take into account not only the benefits but also account for potential costs linked to labor market adjustments. I find that China's integration generate gains worldwide also in the short-run. However, there are winners and losers in the labor market.

My dynamic trade model incorporates search and matching frictions from Pissarides (2000) into a multi-country-sector Costinot, Donaldson, and Komunjer (2012) framework.[1] In this set-up goods can be purchased at home, but consumers will pay the least-cost around the world accounting for trade costs. Hence, consumers benefit from more trade integration by accessing imported goods at lower costs, and workers gain from higher wages and employment levels in sectors that thrive. In my set-up, wages will not be equal across sectors within countries because of labor mobility frictions, which are added to the model assuming that workers have exogenous preferences over sectors (Artuç, Chaudhuri, and McLaren, 2010). On the other hand, a rise in import competition in a sector will decrease wages and increase job destruction in this sector. To analyze how all these effects interact following a trade shock I use numerical simulations.

The "China shock" used in my numerical exercise consists of a decrease in Chinese trade barriers and an increase in Chinese productivity that emulates the growth rate of China's trade volume following its entry into the WTO. I find that all economies gain from this shock. For example, welfare in the United States (USA) and in the United Kingdom (UK) increase by approximately 0.6% and 1.2%, respectively, in the new steady state compared to the initial one.

[1] This is a multi-sector version of Eaton and Kortum (2002) where labor is the solely factor of production.

The effects of the shock on wages and unemployment are heterogeneous across sectors within countries. In mid-tech manufacturing industries in the UK and in the USA, which face severe import competition from China, workers' real wages fall and unemployment rises. The fall in the real average wage in this sector is approximately 0.2% in the USA and 0.7% in the UK during the adjustment period two years after the shock. However, at the same point in time workers in the service and high-tech manufacturing sectors experience a rise in the real average wage and a fall in the unemployment rate: The real average wage in high-tech manufacturing increases by 1% in the USA and in the UK.

The numerical exercise also demonstrates the dynamic effects associated with the rise of China. Immediately after the shock, real wages rise in exporting sectors and fall in industries facing fierce import competition from China. As workers move from sectors hit badly by China in search of better paid jobs in other industries, wages in exporting sectors start to fall due to a rise in labor supply. This implies that wages are lower in the final steady state than during the transition in these industries. In some import competing sectors, however, the effects go in the opposite direction: Wages fall immediately after the shock and recover over time.[2]

The second contribution of this paper is to provide a theoretical foundation to the interpretation of reduced form regressions in the trade-labor literature. In order to do so, I use my model to simulate workers' wages and employment history over several years following the China shock. Then, by building on Autor, Dorn, Hanson, and Song (2014) and Pessoa (2018), I run reduced form regressions using the model-based simulated data. Despite the immense methodological differences, my results are not very different from the ones found in the two papers. For example, Autor, Dorn, Hanson, and Song (2014) find that workers in manufacturing industries more exposed to Chinese imports observed their income fall by 2.86% more (in annual terms) than employees in industries not so strongly exposed to competition with China, while I find an effect of 2.46% using the simulated data.

Differently from the reduced form literature, however, my simulated exercise is based on a general equilibrium model that allows welfare counterfactual analysis. It provides

[2] Artuç, Chaudhuri, and McLaren (2010) find similar overshooting and undershooting effects considering theoretical frameworks that take into account labor mobility frictions between sectors. Bellon (2017) provides evidence that wage dispersion and inequality are higher in the short-run than in the long-run following a trade liberalization episode, while Dix-Carneiro and Kovak (2015) find the opposite pattern using Brazilian data.

evidence that reduced form regressions are able to capture the *relative* negative effects associated with the rise of China, but not the fact that workers in the UK and in the USA experience a rise in welfare and aggregate employment gains due to more trade with China.

In order to perform the analysis in the paper, I estimate a sub-set of the parameters of the model using country-sector level and worker level data. I estimate a gravity equation delivered by the model using data on bilateral trade flows to obtain the trade elasticity parameter and countries' productivity shifters. I also use equations from my theoretical framework and the methodology developed in Artuç and McLaren (2015) to estimate the parameters related to labor mobility frictions between sectors. The remaining parameters are either calibrated or taken from the literature.

Many other papers study the effects of trade openness on labor markets by quantifying theoretical models. However, to my knowledge this is the first paper that explicitly quantifies the effects of a trade shock, the emergence of China, analyzing all the following aspects: general equilibrium effects across countries, the dynamic adjustment path to a new equilibrium (in a set-up where jobs can be endogenously destroyed and with sector-specific unemployment) and labor mobility frictions between sectors.[3]

An example of a paper that quantifies the effects of a trade shock on labor markets is Artuç, Chaudhuri, and McLaren (2010), where the authors consider a dynamic model with labor mobility frictions across sectors. They estimate the variance of USA workers' industry switching costs using gross flows across industries and simulate a trade liberalization shock. This and other papers in this literature, however, consider a small open

[3] Caliendo, Dvorkin, and Parro (2017) develop a dynamic trade model with full employment that takes into account labor mobility frictions, goods mobility frictions, geographic factors and input-output linkages. They calibrate the model to 22 sectors, 38 countries and 50 states in the USA to quantify the effects of the China shock. They find that China was responsible for the destruction of thousands of jobs in manufacturing in the USA, but the shock generated aggregate welfare gains. di Giovanni, Levchenko, and Zhang (2014) evaluate the welfare impact of China's integration considering a multi-sector, multi-country framework and also find that welfare increases in developed economies. Levchenko and Zhang (2013) study not only the aggregate but also the distributional impacts of the trade integration of China and other developing economies considering factor immobility, finding that reallocation of factors across sectors contributes relatively little for aggregate gains, but has large distributional impacts. Both papers, however, consider a static framework with full-employment.

economy set-up, disregarding general equilibrium effects across countries.[4]

Another strand of the literature quantifies models in which labor markets are imperfect taking into account general equilibrium effects across countries, but usually ignore multi-sector economies (and consequently that workers do not move freely between sectors) and are silent about transitional dynamics, due to the static nature of their framework. The most similar paper to mine in this area is Heid and Larch (2016), that considers search generated unemployment in an Arkolakis, Costinot, and Rodriguez-Clare (2012) environment and calculate international trade welfare effects in the absence of full employment.[5]

The interpretation of reduced form regressions using simulated data contributes to the empirical literature that uses worker level information to identify effects of international trade on labor market outcomes, including out of employment dynamics. Examples are Autor, Dorn, Hanson, and Song (2014) and Pessoa (2018), which consider the China shock to identify impacts on labor markets in the USA and in the UK, respectively.[6]

The paper is organized as follows. In Section 2 I present my model and discuss some of its implications. In Section 3 I structurally estimate a sub-set of the parameters of the model, and explain how to calibrate the remaining parameters. In Section 4 I compute my counterfactual and simulation exercises and present their results. I offer concluding comments in Section 5.

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[4] Another interesting paper is Dix-Carneiro (2014), which estimates a dynamic model using Brazilian micro-data to study the adjustment path after a Brazilian trade liberalization episode in the nineties. Utar (2011) calibrates a model using Brazilian data to answer a similar question, while Helpman, Itskhoki, Muendler, and Redding (2012) use linked employer-employee data to analyze also the trade effects in this same country, but with a greater focus on wage inequality. Cosar, Guner, and Tybout (2013) and Utar (2006) use Colombian firm level data to estimate a dynamic model of labor adjustment and study how the economy fairs following an import competition shock. Kambourov (2009) builds a dynamic general equilibrium sectoral model of a small open economy with sector-specific human capital, firing costs and tariff. He calibrates the model using Chilean and Mexican data to quantify the effects of trade reforms that took place in the seventies and in the eighties in Chile and in Mexico, respectively, finding that if a country does not liberalize its labor market at the outset of its trade reform, the reallocation of workers across sectors will be slower, reducing the gains from trade.

[5] Felbermayr, Larch, and Lechthaler (2013) construct a static one sector Armington model with frictions on the goods and labor markets and use a panel data of developed countries to verify the predictions of the model. Felbermayr, Impullitti, and Prat (2014) builds a dynamic two country one sector model a la Melitz (2003) to study inequality response to trade shocks in Germany, but consider only a static framework in their calibration exercise using matched employer-employee data from Germany.

[6] More broadly, the paper adds to a growing literature on the effects of trade shocks on labor markets, such as Pfaffermayr, Egger, and Weber (2007), Revenga (1992), Bernard, Jensen, and Schott (2006), Filho and Muendler (2007), Dauth, Findeisen, and Suedekum (2012), Kovak (2013), Autor, Dorn, and Hanson (2013) and Costa, Garred, and Pessoa (2016), to cite just a few.

2 Model

My dynamic trade model incorporates frictional unemployment with endogenous job destruction (Pissarides, 2000) into a multi-country/multi-sector Costinot, Donaldson, and Komunjer (2012) framework. I also add labor mobility frictions between sectors using some features from Artuç, Chaudhuri, and McLaren (2010).

The model takes into account that labor markets are imperfect. The economy is composed of many countries and sectors. Workers without a job can choose the sector in which to search for employment according to their personal exogenous preferences. Within a sector, firms and workers have to engage in a costly and uncoordinated process to meet each other. Each sector produces many types of varieties, and consumers will shop around and pay the best available price for each type of variety (considering trade costs).

The model is tractable and allows the ability to quantify changes in real income per capita and welfare following a trade shock (the emergence of China) considering not only the positive aspects associated with cheaper consumption goods but also the potential negative aspects associated with labor market adjustments. My dynamic framework will also enable me to study how different groups of workers are affected at different points in time. I start the section by providing the main components of the model. I then demonstrate how to compute the equilibrium and discuss some of the implications of the model.

In terms of notation, $a^t_{k,i}$ represents variable 'a' in sector k in country i at time t. Some variables represent a bilateral relationship between two countries. In this case, the variable $a^t_{k,oi}$ is related to exporter o and importer i in sector k. Finally, in other cases it will be necessary to highlight that a variable depends on a worker, on a variety or on a different productivity level. In such cases, $a^t_{k,i}(l)$ means that the variable is related to the worker l, $a^t_{k,i}(j)$ is a variable associated with the variety j and $a^t_{k,i}(x)$ is linked to idiosyncratic productivity x. For the sake of simplicity, I omit the variety index j whenever possible.

2.1 Consumers

There are N countries. Each country has an exogenous labor force L_i and is formed by K sectors containing an (endogenous) mass of workers $L^t_{k,i}$ and an infinite mass of potential entrant firms. I assume that heterogeneous family members in each country pool their income, which is composed of unemployment benefits, labor income, firm profits and government lump-sum transfers/taxes, and maximize an inner C.E.S, outer Cobb-Douglas utility function subject to their income in period t:[7]

$$Max \sum_k \mu_{k,i} \frac{\ln \int_0^1 (C^t_{k,i}(j))^{\varepsilon} dj}{\varepsilon},$$

where k indexes sectors, $\varepsilon = (\sigma - 1)/\sigma$, σ is the constant elasticity of substitution (between varieties) and $C^t_{k,i}(j)$ represents consumption of variety j (and the utility function is expressed in log terms). $\mu_{k,i}$ is country i's share of expenditure on goods from sector k, and $\sum_k \mu_{k,i} = 1$. Note that consumers do not save in this economy. The dynamic effects in the model arise from labor market features, as shown below.

2.2 Labor Markets

Each sector has a continuum of varieties $j \in [0,1]$. I treat a variety as an ex-ante different labor market. I omit the variety index j from this point forward, but the reader should keep in mind that the following expressions are country-sector-variety specific.

Firms and workers have to take part in a costly matching process to meet each other in a given market. This process is governed by a matching function $m(u^t_{k,i}, v^t_{k,i})$. It denotes the number of successful matches that occur at a point in time when the unemployment rate is $u^t_{k,i}$ and the number of vacancies posted is $v^t_{k,i}$ (where $u^t_{k,i}$, $v^t_{k,i}$ and $m()$ are expressed as fractions of the labor force). As in Pissarides (2000), I assume that the matching function is increasing in both arguments, concave and homogeneous of degree 1. Homogeneity implies that labor market outcomes are invariant to the size of the labor force in the market. For convenience, I work with $\theta^t_{k,i} = v^t_{k,i}/u^t_{k,i}$, a measure of labor market tightness. So the probability that any vacancy is matched with an unemployed worker is given by

$$\frac{m(u^t_{k,i}, v^t_{k,i})}{v^t_{k,i}} = q(\theta^t_{k,i}),$$

[7] Under the assumption of a "big household" with heterogeneous individuals (employed/unemployed in different sectors), and that households own some share of firms, household consumption equals its income $Consumption^t_i = Income^t_i = Wages^t_i + Profits^t_i + UnempBenefits^t_i + Tgov^t_i$
The government uses lump-sum taxes/transfers $Tgov^t_i$ to pay unemployment benefits and finance vacancy costs.

and the probability that an unemployed worker is matched with an open vacancy is

$$\frac{m(u^t_{k,i}, v^t_{k,i})}{u^t_{k,i}} = \theta^t_{k,i} q(\theta^t_{k,i}).$$

Workers are free to move between markets to look for a job but not between sectors as will become clearer later. Unemployed workers receive a constant unemployment benefit $b_{k,i}$ while looking for a job in sector k.[8] New entrant firms are also free to choose a market in which to post a vacancy and are constrained to post a single vacancy. While the vacancy is open they have to pay a per period cost equals to κ times the productivity of the firm.

Jobs have productivity $z_{k,i}x$. x is a firm specific component, which changes over time according to idiosyncratic shocks that arrive to jobs with probability 1, changing the productivity to a new value x', independent of x and drawn from a distribution $G(x)$ with support $[0,1]$. Hence, there is no persistence in the idiosyncratic productivity of the job. $z_{k,i}$ is a component common to all firms within a variety, constant over time and taken as given by the firm (I postpone its description until Sub-section 2.5).

After firms and workers meet, production starts in the subsequent period. Firms are price takers and their revenue will be equal to $p^t_{k,i} z_{k,i} x$. During production periods, firms pay a wage $w^t_{k,i}(x)$ to employees, and each firm employs (at most) a single worker.

When jobs face any type of shock (including the idiosyncratic one), firms have the option of destroying it or continuing production. Let $J^t_{k,i}(x)$ be the value of a filled vacancy for a firm. Then, production ceases when $J^t_{k,i}(x) < 0$ and continues otherwise. So, job destruction takes place when x falls below a reservation level $R^t_{k,i}$, where $J^t_{k,i}(R^t_{k,i}) = 0$. Defining the expected value of an open vacancy as $V^t_{k,i}$, I can write value functions that govern firms' behavior:

$$V^t_{k,i} = -\kappa p^t_{k,i} z_{k,i} + \frac{1}{1+r}[q(\theta^t_{k,i}) \int_{R^{t+1}_{k,i}}^{1} J^{t+1}_{k,i}(s) dG(s) + (1 - q(\theta^t_{k,i})) V^{t+1}_{k,i}]. \quad (1)$$

[8]It is more common to assume that unemployment benefits are common across sectors. The assumption that the value of unemployment benefits varies by sector is not key to derive the model predictions, but it helps to match the model to the data.

$$J^t_{k,i}(x) = p^t_{k,i} z_{k,i} x - w^t_{k,i}(x) + \frac{1}{1+r}[\int_{R^{t+1}_{k,i}}^{1} J^{t+1}_{k,i}(s)dG(s)]. \tag{2}$$

The value of an open vacancy is equal to the per-period vacancy cost plus the future value of the vacancy. The latter term is equal to the probability that the vacancy is filled, $q(\theta^t_{k,i})$, times the value of a filled vacancy next period, $\int_{R^{t+1}_{k,i}}^{1} J^{t+1}_{k,i}(s)dG(s)$, plus the probability that the vacancy is not filled multiplied by the value of an open vacancy in the future, all discounted by $1+r$.

I am implicitly assuming that firms are not credit constrained, even though some papers, e.g. (Manova, 2008), argue that financial frictions matter in international trade. So, governments will lend money to firms (financed by lump-sum taxes on consumers) as long as the value of posting a vacancy is greater or equal to zero. The value of a filled job is given by the per period revenue minus the wage cost plus the expected discounted value of the job in the future. The last term is equal to the expected value of the job next period, $\int_{R^{t+1}_{k,i}}^{1} J^{t+1}_{k,i}(s)dG(s)$.

From the worker side, unemployed individuals decide in which sector to look for a job in the end of each period, and in contrast to the variety case (described later), they do not move freely between sectors. I assume that each individual has a (unobserved by the econometrician) preference $\nu^t_{k,i}(l)$ for each sector, an idiosyncratic worker-sector-time specific component.

A high $\nu^t_{k,i}(l)$ relative to $\nu^t_{k',i}(l)$ means that the worker has some advantage of looking for jobs in sector k relative to sector k', for example, because he/she prefers to work in industry k as it is located in an area where he/she owns a property or his/her family members are settled. I do not provide a more detailed micro foundation for these components to keep the model as simple as possible.

Following great part of the labor and industrial organization literatures, I assume that $\nu^t_{k,i}(l)$ are i.i.d. across individuals, time and industries, following a type I extreme value (or Gumbel) distribution with parameters $(-\gamma\zeta_i, \zeta_i)$.[9] The parameter ζ_i, which governs the variance of the shock, reflects how important non-pecuniary motives are to a worker's decision to switch sectors. When ζ_i is very large, pecuniary reasons play almost no role

[9]The Gumbel cumulative distribution with parameters $(-\gamma\zeta_i, \zeta_i)$ is given by $S(z) = e^{-e^{-(z-\gamma\zeta_i)/\zeta_i}}$ and I have that $E(z) = -\gamma\zeta_i + \gamma\zeta_i = 0$ and $Var(z) = \pi^2\zeta_i^2/6$, where $\pi \approx 3.1415$ and $\gamma \approx 0.5772$.

and workers will respond less to wage (or probability of finding a job) differences across sectors. In the polar case of ζ_i going to infinity, workers are fixed in a particular industry. When ζ_i is small the opposite is true and workers tend to move relatively more across sectors following unexpected changes in sectoral unemployment values.

This assumption implies a tractable way of adding labor mobility frictions to the model. In my counterfactual exercise, I will be able to analyze how different levels of mobility frictions influence the impacts on several outcomes following a trade shock. It also incorporates an interesting effect on the model: It allows sectors with high wages and high job-finding rates to coexist in equilibrium with sectors with low wages and low job-finding rates. If there were no frictions (workers were completely free to move) sectors with higher wages would necessarily have lower job-finding rates (as long as the value of posting vacancies were equal to zero in both sectors).

Workers also bear a cost $C_{k\bar{k},i}$ when moving from sector k to $\bar{k}$. This cost will be zero when an unemployed worker does not leave her current sector ($C_{kk,i} = 0$). Hence in the end of the period, after production and job creation/destruction have taken place but before the realization of the $\nu^t_{k,i}(l)$'s , unemployed workers in sector k expect to get

$$\begin{aligned} \Omega^t_{k,i} &= E_\nu[max_{\bar{k}}\{\nu^t_{\bar{k},i}(l) - C_{k\bar{k},i} + \frac{U^{t+1}_{\bar{k},i}}{1+r} - \frac{U^{t+1}_{k,i}}{1+r}\}] \\ &= \zeta_i log[\sum_{\bar{k}} exp(\frac{U^{t+1}_{\bar{k},i}}{(1+r)\zeta_i} - \frac{U^{t+1}_{k,i}}{(1+r)\zeta_i} - \frac{C_{k\bar{k},i}}{\zeta_i})], \end{aligned} \tag{3}$$

where the expectation is taken w.r.t. the $\nu^t_{k,i}(l)$'s. $\Omega^t_{k,i}$ is the continuation value of workers attached to sector k at time t. This will be an important component of the expected unemployment value of workers looking for a job in sector k at the start of period t (and before workers learn their values of $\nu^t_{k,i}(l)$), defined as:

$$\begin{aligned} U^t_{k,i} &= b_{k,i} + \eta_{k,i} + [1 - \theta^t_{k,i}q(\theta^t_{k,i})(1 - G(R^{t+1}_{k,i}))]\Omega^t_{k,i} \\ &+ \frac{1}{1+r}[\theta^t_{k,i}q(\theta^t_{k,i}) \int_{R^{t+1}_{k,i}}^{1} W^{t+1}_{k,i}(s)dG(s) + (1 - \theta^t_{k,i}q(\theta^t_{k,i})(1 - G(R^{t+1}_{k,i})))U^{t+1}_{k,i}]. \end{aligned} \tag{4}$$

The expected unemployment value is equal to the per period unemployment benefit plus the discounted expected value of the job next period, given that workers get employed with probability $\theta^t_{k,i}q(\theta^t_{k,i})$, but they may immediately lose their jobs with probability $G(R^{t+1}_{k,i})$. Put another way, a worker at time t will actually produce next period if she finds a firm and does not draw a value of x below $R^{t+1}_{k,i}$. In such a case, the worker expects to get $\int_{R^{t+1}_{k,i}}^{1} W^{t+1}_{k,i}(s)dG(s)$. If the worker does not find a firm or find one and immediately draws a bad idiosyncratic shock, an event that takes place with probability $1-\theta^t_{k,i}q(\theta^t_{k,i})(1-G(R^{t+1}_{k,i}))$, she gets the unemployment value next period, $U^{t+1}_{k,i}$, plus the option value of moving across sectors, $\Omega^t_{k,i}$.[10]

The term $\eta_{k,i}$ is a non-stochastic component that reflects the attractiveness of a sector, common to all workers. It is known by individuals but not by the econometrician.

$W^t_{k,i}(x)$ is the expected value of a job with productivity x for a worker (before he/she learns his/her values of $\nu^t_{k,i}(l)$). It is given by the per-period wage plus $\eta_{k,i}$ and a dynamic component:

$$\begin{aligned} W^t_{k,i}(x) = {} & w^t_{k,i}(x) + \eta_{k,i} + G(R^{t+1}_{k,i})\Omega^t_{k,i} \\ & + \frac{1}{1+r}\Big[\int_{R^{t+1}_{k,i}}^{1} W^{t+1}_{k,i}(s)dG(s) + G(R^{t+1}_{k,i})U^{t+1}_{k,i}\Big]. \end{aligned} \tag{5}$$

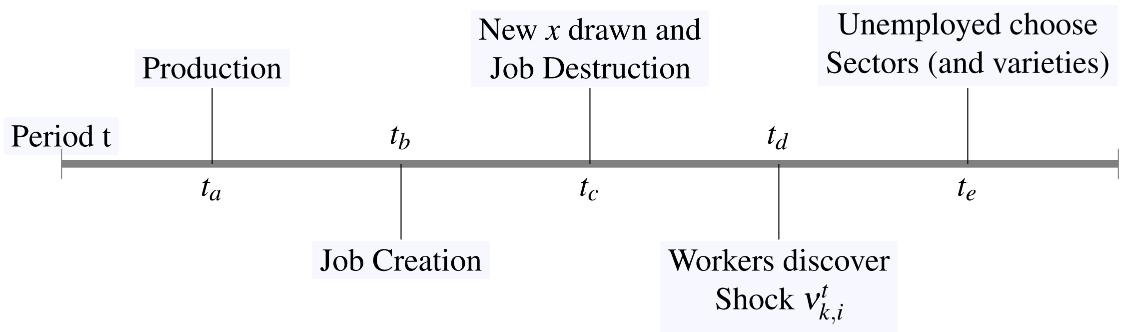
After a new draw of x, if productivity remains above the destruction threshold, then the worker gets on average $\int_{R^{t+1}_{k,i}}^{1} W^{t+1}_{k,i}(s)dG(s)$. On the other hand, with probability $G(R^{t+1}_{k,i})$ the shock will be sufficiently bad to drive the worker into unemployment and she obtains only $U^{t+1}_{k,i}$ next period plus an option value of moving across sectors, $\Omega^t_{k,i}$.

Figure 1 summarizes how labor markets function in the model. At the start of period t, production takes place, workers get wages and unemployed workers get their unemployment benefits. Then job creation occurs and all matches (including the newly formed ones) draw a new productivity shock x, which is followed by job destruction in the economy. Finally, workers realize their idiosyncratic moving shock $\nu^t_{k,i}$ and decide whether to move across sectors (and varieties).[11]

[10]Note that $\Omega^t_{k,i}$ is discounted from the unemployment value in the worker's current sector.

[11]Note that I am implicitly assuming that all agents have rational expectations and perfect foresight of aggregate variables.

Figure 1: Labor Market Summary



2.3 Wages, Mobility within Sectors and Firms Entry/Exit

Wages are determined by means of a Nash bargaining process, where employees have exogenous bargaining power $0 < \beta_{k,i} < 1$. Hence, the surplus that accrues to workers must be equal to a fraction $\beta_{k,i}$ of the total surplus,

$$W^t_{k,i}(x) - U^t_{k,i} = \beta_{k,i}(J^t_{k,i}(x) + W^t_{k,i}(x) - U^t_{k,i} - V^t_{k,i}). \tag{6}$$

Note that workers and firms are free to look for jobs and to open vacancies across varieties. Hence, at every point in time the unemployment value must be equal for all varieties that are produced in equilibrium. Because markets are competitive, firms cannot obtain rents from opening vacancies. This implies that the value of a vacancy will be equal to zero in any market inside a country. These two conditions can be summarized as follows,

$$U^t_{k,i}(j) = U^t_{k,i}(j') \tag{7}$$

$$V^t_{k,i}(j) = V^t_{k,i}(j') = 0, \tag{8}$$

where here I explicitly indicate that the unemployment value and the value of an open vacancy are ex-ante market specific. The fact that unemployment values are equalized across different varieties (condition 7) implies that $p^t_{k,i}z_{k,i}$ must be equal across markets that produce in equilibrium (I provide more details about this result in Appendix A.1):[12]

[12] Intuitively, note that cross market arbitrage by entrant firms must hold, $q(\theta^t_{k,i}(j))(1-\beta_{k,i})\Xi^t_{k,i}(j) = q(\theta^t_{k,i}(j'))(1-\beta_{k,i})\Xi^t_{k,i}(j')$, where $\Xi^t_{k,i}(j)$ is the expected total surplus in market j. Similarly, worker arbitrage implies $\theta^t_{k,i}(j)q(\theta^t_{k,i}(j))\beta_{k,i}\Xi^t_{k,i}(j) = \theta^t_{k,i}(j')q(\theta^t_{k,i}(j'))\beta_{k,i}\Xi^t_{k,i}(j')$. Taking the ratio between the two arbitrage conditions, I get that $\theta^t_{k,i}(j) = \theta^t_{k,i}(j')$. And given that expected surpluses are increasing in $p^t_{k,i}(j)z_{k,i}(j)$, either arbitrage condition implies that $p^t_{k,i}z_{k,i}$ must be equal across markets.

$$p^t_{k,i}(j)z_{k,i}(j) = p^t_{k,i}(j')z_{k,i}(j').$$

Hence, the only possible equilibrium is a symmetric one where $\theta^t_{k,i}$ and $p^t_{k,i}z_{k,i}$ are equalized across varieties inside a sector in a country. Hence, all varieties also have the same labor market outcomes $R^t_{k,i}$ and $u^t_{k,i}$, as well as the same wage distribution. As will be discussed below, the only variety dependent variable is the price.

I obtain a wage equation by manipulating the value functions:[13]

$$\begin{aligned} w^t_{k,i}(x) = (1-\beta_{k,i})b_{k,i} + \beta_{k,i}p^t_{k,i}z_{k,i}(x+\kappa\theta^t_{k,i}) \\ + (1-\beta_{k,i})[1-\theta^t_{k,i}q(\theta^t_{k,i})(1-G(R^{t+1}_{k,i})) - G(R^{t+1}_{k,i})]\Omega^t_{k,i} \end{aligned} \tag{9}$$

Wages are increasing in productivity and unemployment benefits. The option value of moving across sectors, $\Omega^t_{k,i}$, also increase workers' wages. This term appears multiplied by the probability of staying unemployed if you start the period in such state, $1-\theta^t_{k,i}q(\theta^t_{k,i})(1-G(R^{t+1}_{k,i}))$, adjusted by the probability of becoming unemployed if you start the period with a job, $G(R^{t+1}_{k,i})$. Better wages and fewer difficulties to find jobs in other sectors will increase this option value, and hence, increase wages in sector k.

Free entry in the activity of posting vacancies (Condition 8) and the fact that only jobs with idiosyncratic productivity $x > R^t_{k,i}$ will exist at time t ($J^t_{k,i}(R^t_{k,i}) = 0$) result in two other key equilibrium relationships: The job creation and the job destruction equations (both derived in Appendix A.2).

2.4 Flow of Workers

After production but before workers decide on a sector to look for an open vacancy, job creation and job destruction take place in this economy. The number of jobs created as a fraction of the labor force in the sector is equal to

$$JC^t_{k,i} \equiv u^t_{k,i}\theta^t_{k,i}q(\theta^t_{k,i})(1-G(R^{t+1}_{k,i})), \tag{10}$$

[13] To find the wage equation, I first integrate 6 over the interval $[R^{t+1}_{k,i}, 1]$. Second, I set $V^t_{k,i} = 0$ in 1. Using these two results and 4, I find $U^t_{k,i} - U^{t+}_{k,i}/(1+r) = b_{k,i} + \eta^t_k + \beta_{k,i}p^t_{k,i}z_{k,i}\kappa\theta^t_{k,i}/(1-\beta_{k,i}) + [1-\theta^t_{k,i}q(\theta^t_{k,i})(1-G(R^{t+1}_{k,i}))]\Omega^t_{k,i}$. Third, I subtract $\beta_{k,i}$ times Equation 2 from $1-\beta_{k,i}$ times 5. By combining this difference with $U^t_{k,i} - U^{t+}_{k,i}/(1+r)$ and the integral of 6, I get 9.

while the expression for jobs destroyed is

$$JD^t_{k,i} \equiv G(R^{t+1}_{k,i})(1-u^t_{k,i}). \tag{11}$$

Hence, the rate of unemployment in the end of the period (before workers move) is given by:

$$\tilde{u}^t_{k,i} = u^t_{k,i} - JC^t_{k,i} + JD^t_{k,i}, \tag{12}$$

where $\tilde{u}^t_{k,i}$ represents the fraction of unemployed at the end of the period, while $u^t_{k,i}$ represents the rate at the start of the period. Notice that this process takes place at the variety level, but the fact that the varieties are symmetric will permit me to easily aggregate it up to the sector level.

Remember that by the end of the period an unemployed worker will get to know her $\nu^t_{k,i}(l)$'s and decide whether to switch sectors or not by choosing k' that maximizes $\nu^t_{k',i}(l) - C_{kk',i} + \frac{U^{t+1}_{k',i}}{1+r} - \frac{U^{t+1}_{k,i}}{1+r}$. Under the Gumbel distributional assumption, the probability that an unemployed worker in sector k will end up looking for a job in sector k' is given by:

$$s^t_{kk',i} = \frac{exp(\frac{U^{t+1}_{k',i}}{(1+r)\zeta_i} - \frac{U^{t+1}_{k,i}}{(1+r)\zeta_i} - \frac{C_{kk',i}}{\zeta_i})}{\sum_{\bar{k}} exp(\frac{U^{t+1}_{\bar{k},i}}{(1+r)\zeta_i} - \frac{U^{t+1}_{k,i}}{(1+r)\zeta_i} - \frac{C_{k\bar{k},i}}{\zeta_i})}. \tag{13}$$

This will be the share of unemployed individuals switching from sector k to k' at the end of period t. Hence, the outflow and inflow of workers in a sector are, respectively,

$$OF^t_{k,i} \equiv \sum_{k'} s^t_{kk',i} L^t_{k,i} \tilde{u}^t_{k,i}, \tag{14}$$

and

$$IF^t_{k,i} \equiv \sum_{k'} s^t_{k'k,i} L^t_{k',i} \tilde{u}^t_{k',i}, \tag{15}$$

where $L^t_{k,i}$ is the labor force in a sector at the start of period t. The number of unemployed individuals in sector k at the beginning of period $t+1$, $L^{t+1}_{k,i} u^{t+1}_{k,i}$, will be equal to $IF^t_{k,i}$.

2.5 International Trade

All goods are tradable. Each variety j from sector k can be purchased at home at price $p^t_{k,i}(j)$ (which is equivalent to the term $p^t_{k,i}$ used in my description of the labor market, the only difference being that I now make explicit that it is a country-market specific variable), but local consumers can take advantage of the option provided by a foreign country and pay a better price. In short, consumers will pay for variety j the $min\{d_{k,oi}\, p^t_{k,o}(j); o = 1,...,N\}$, where $d_{k,oi}$ is an iceberg transportation cost between exporter o and importer i, meaning that delivering a unit of the good requires producing $d_{k,oi} > 1$ units. I assume that $d_{k,ii} = 1$ and that is always more expensive to triangulate products around the world than exporting goods bilaterally ($d_{k,oi}d_{k,ii'} > d_{k,oi'}$).

In any country i, the productivity component $z_{k,i}$ is drawn from a Frechet distribution $F_{k,i}(z) = e^{-(A_{k,i})^{\lambda} z^{-\lambda}}$, i.i.d for each variety in a sector. The parameter $A_{k,i} > 0$ is related to the location of the distribution: A bigger $A_{k,i}$ implies that a higher efficiency draw is more likely for any variety. It reflects home country's absolute advantage in the sector. $\lambda > 1$ pins down the amount of variation within the distribution and is related to comparative advantage: a lower λ implies more variability, i.e., comparative advantage will exert a stronger force in international trade.

As in Eaton and Kortum (2002), the fact that consumers shop for the best price around the world implies that each country i will spend a share $\pi^t_{k,oi}$ of its income on goods from country o in sector k.

Symmetric varieties will permit me to find relatively simple expressions for the trade shares of each country around the world. Since the term $p^t_{k,i}z_{k,i}$ is constant across varieties and $z_{k,i}$ is a random variable, it must be that the price of each variety is also a random variable inversely proportional to $z_{k,i}$. There are some ways to see this. One of them is to use my wage equation 9 to find the highest wage in the sector, $w^t_{k,i}(1)$, and subtract from it the lowest wage, $w^t_{k,i}(R^t_{k,i})$. This will imply that:

$$p^t_{k,i}(j) = \frac{1}{z_{k,i}(j)} \frac{w^t_{k,i}(1) - w^t_{k,i}(R^t_{k,i})}{\beta_{k,i}(1 - R^t_{k,i})} = \frac{\tilde{w}^t_{k,i}}{z_{k,i}(j)}. \tag{16}$$

$\tilde{w}^t_{k,i}$ is simply a way of writing the slope of the wage profile in the sector. For everything else constant, a steeper wage profile implies that the wage bill in the country is higher, and prices will also be higher.

I am now in the position to calculate trade shares around the world. Given iceberg trade costs, prices of goods shipped between an exporter o and an importer i are a draw from the random variable $P^t_{k,oi} = \frac{d_{k,oi}\tilde{w}^t_{k,o}}{Z_{k,o}}$. The probability that country o offers the cheapest price in country i is $Pr(P^t_{k,oi} \leq p) = 1 - e^{-(pA_{k,o}/d_{k,oi}\tilde{w}^t_{k,o})^{\lambda}}$. And since consumers will pay the minimum price around the world, I have that the distribution of prices actually paid by country i is

$$H^t_{k,i}(p) = 1 - \prod_{o'=1}^{N}(1 - Pr(P^t_{k,o'i} \leq p)) = 1 - e^{-\Phi^t_{k,i}p^{\lambda}},$$

where $\Phi^t_{k,i} = \sum_{o'}(A_{k,o'}/d_{k,o'i}\tilde{w}^t_{k,o'})^{\lambda}$, is the parameter that guides how labor market variables, technologies and trade costs around the world govern prices. Each country takes advantage of international technologies, discounted by trade costs and the wage profile of each country.

Hence, I can calculate the exact price index,

$$P^t_i = \prod_k (P^t_{k,i})^{\mu_{k,i}}, \tag{17}$$

where $P^t_{k,i} = \psi(\Phi^t_{k,i})^{(-1/\lambda)}$, $\psi = [\Gamma(\frac{\lambda+1-\sigma}{\lambda})]^{1/(1-\sigma)}$ and Γ is the Gamma function (remember that $\mu_{k,i}$ is the share of country i's income allocated to consumption of sector k goods).

As in Eaton and Kortum (2002), I calculate the probability that a country o provides a good at the lowest price in country i in a given sector:

$$\pi^t_{k,oi} = \frac{(A_{k,o}/d_{k,oi}\tilde{w}^t_{k,o})^{\lambda}}{\Phi_{k,i}}. \tag{18}$$

$\pi^t_{k,oi}$ decreases with labor costs of exporter o (or with trade costs $d_{k,oi}$), and increases with absolute advantage of exporter o.

Eaton and Kortum also show that the price per variety, conditional on the variety being supplied to the country, does not depend on the origin, i.e., the price of a good that i actually buys from any exporter o also has the distribution $H^t_{k,i}(p)$. This implies that average expenditure does not vary by country of origin. Exporters with cheaper wages or with lower trade costs take advantage by exporting a wider range of goods. Because there is a continuum of goods, it must be that the expenditure share of country i on varieties coming from o is given by the probability that o supplies a variety to i,

$$\frac{X^t_{k,oi}}{X^t_{k,i}} = \pi^t_{k,oi}, \tag{19}$$

where $X^t_{k,oi}$ is country i's expenditure on goods from o, and $X^t_{k,i} = \sum_{o'} X^t_{k,o'i}$ is its total expenditure in a given sector.

To close the model I find an expression for total revenue by country-sector pair

$$Y^t_{k,o} = \tilde{w}^t_{k,o} L^t_{k,o}(1-u^t_{k,o}) \int_{R^t_{k,o}}^{1} \frac{s}{1-G(R^t_{k,o})} dG(s), \tag{20}$$

and use the fact that markets must clear

$$Y^t_{k,o} = \sum_{i'} \pi^t_{k,oi'} \mu_{k,i} Y^t_{i'}, \tag{21}$$

where $Y^t_{i'} = \sum_k Y^t_{k,i'} + \xi_{i'}$ is aggregate income in country i', which is given by sales around the world plus some exogenous trade imbalance $\xi_{i'}$, with $\sum_i \xi_i = 0$.[14] Following Krause and Lubik (2007) and Trigari (2006), I am assuming that the governments pay for unemployment benefits and vacancy costs through lump sum taxes/transfers. This implies that aggregate income in a sector is given by the total revenue obtained from sales around the world (plus trade imbalances).

2.6 Steady States and Transition Paths

The steady state equilibria, as well as the transition path between steady states following an unanticipated change in a sub-set of the parameters, are computed numerically. To compute them, I need to find a set of labor force allocations and unemployment rates per sector $\{L^t_{k,i}, u^t_{k,i}\ \forall i,k\}^{\infty}_{t=0}$, share of unemployed individuals moving across sectors $\{s^t_{kk',i}\ \forall i,k,k'\}^{\infty}_{t=0}$, endogenous productivity thresholds and labor market tightness $\{R^t_{k,i}, \theta^t_{k,i}\ \forall i,k\}^{\infty}_{t=0}$, slope of wage profiles[15] $\{\tilde{w}^t_{k,i}\ \forall i,k\}^{\infty}_{t=0}$, value functions (in real terms) $\{U^t_{k,i}, V^t_{k,i}, W^t_{k,i}(x), J^t_{k,i}(x)\ \forall i,k,x\}^{\infty}_{t=0}$ and trade share allocations $\{\pi^t_{k,oi}\ \forall i,o,k\}^{\infty}_{t=0}$ such that:

i. The value functions satisfy Equations 1, 2, 4 and 5 and workers are free to move across varieties within sectors (Equation 7).

[14] In my main exercise I will have that $\xi_i = 0$ for all countries.

[15] Note that $\tilde{w}^t_{k,i}$ and $z_{k,i}(j)$ determine prices $p^t_{k,i}(j)$.

ii. There is free entry in the activity of posting vacancies and unprofitable matches are destroyed, i.e., the job creation (33) and job destruction (34) equations hold - see Appendix A.2.

iii. Wages are determined through Nash bargaining, and hence, given by Equation 9.

iv. Unemployment rates evolve over time according to Equation 12 and the shares of unemployed individuals moving across sectors satisfy Equation 13.

v. Individuals purchase the cheapest products around the world (implying that trade shares are given by Equation 18) and product markets clear (Equation 21).

I provide more details on how to obtain steady state equilibria and transition paths in Appendices B.1 and B.2.

2.7 Preliminary Analysis

Consider a rise in productivity ($A_{k,C}$) in a foreign country C or a fall in trade costs ($d_{k,CU}$ / $d_{k,CU}$) between the same foreign country and home country U, holding productivity in the home country fixed. Consumers in the home country will benefit as they have access to cheaper goods coming from abroad. Sectors will be able to expand and export more to C. Additionally, better conditions in some sectors of U will benefit all workers in the country. This is so because workers' option values ($\Omega^t_{k,U}$) will increase even for those who are not in sectors directly affected by a positive shock.

However, such shocks can also have negative effects in the labor market. If the demand for goods produced locally fall, prices of local goods will fall, implying that jobs will have to be destroyed in the home country and wages will go down.[16] Note that the jobs destroyed in any country-sector following a bad shock are the ones with low idiosyncratic productivity x. These are the low-paid (low-productivity) jobs in the sector that become non-profitable after a fall in prices. Hence, the effect on welfare (and aggregate real income) is ambiguous.[17]

[16] Note that the assumption that the unemployment benefit $b_{k,i}$ is constant plays an important role in my model. It will imply that wages will *not* absorb all the impact from shifts in productivity/prices in the new equilibrium and, consequently, such shocks will have an effect on the unemployment rate even in the long-run.

[17] The effect on wage inequality is also ambiguous, as declining sectors observe a fall in wage inequality while the opposite happens in thriving ones. Helpman, Itskhoki, and Redding (2010) show that if a sector has some firms that export and others that do not, trade openness will exacerbate wage inequality. This is due to the fact that exporting firms, that pay higher wages, become larger than the ones that do not.

Workers have preferences over sectors in my model. This means that after a trade shock some (but not all) unemployed workers will be willing to move from sectors that experience losses and to start looking for jobs in other sectors. Which sectors lose or gain in each country will depend on the new configuration of comparative and absolute advantages around the world following the trade/productivity shock.

To further understand how welfare responds to analogous trade shocks, I run two preliminary numerical exercises to analyze how changes in parameters $A_{k,C}$ and $d_{k,CU}$ / $d_{k,UC}$ affect welfare values across steady states of the economy. To compute welfare in country i, I use a weighted value function measure defined as:

$$VF_i^t = \sum_k L_{k,i}^t \left[(1 - u_{k,i}^t)\bar{W}_{k,i}^t + u_{k,i}^t U_{k,i}^t \right], \tag{22}$$

where $\bar{W}_{k,i}^t$ denotes the average (over idiosyncratic productivity x) value function for a worker in sector k.

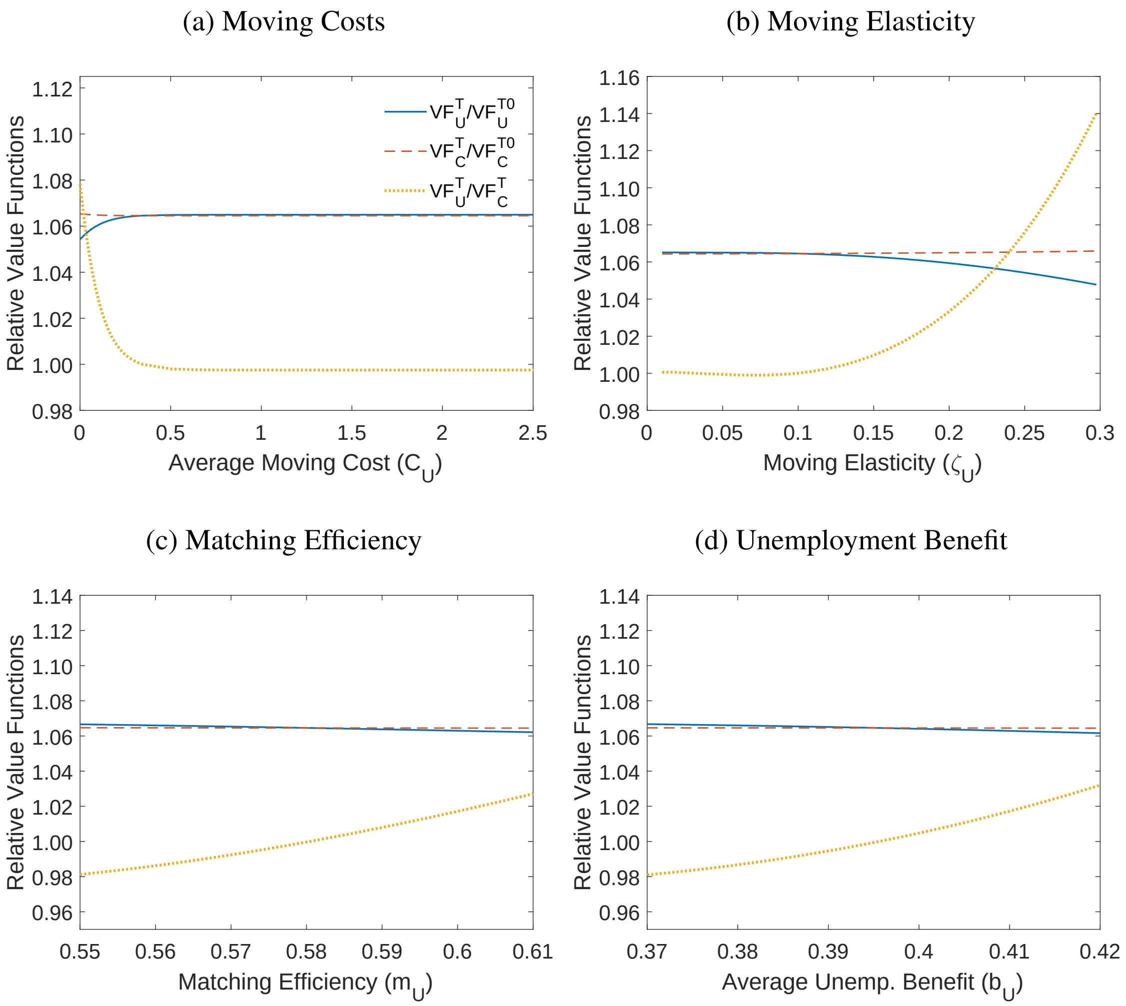
I consider a preliminary world configuration with three sectors (services, manufacturing and agriculture/mining) and two symmetric economies, U and C, "similar" to the USA in 2005 in terms of labor force size allocated to each sector, (aggregate) unemployment and labor mobility frictions across sectors.[18]

Figure 2a shows relative welfare values after trade costs decrease from $d_{k,CU} = d_{k,UC} = 1.05$ at time $T0$ to $d_{k,CU} = d_{k,UC} = 1$ at time T in the agricultural and manufacturing sectors in both countries for different values of moving costs across sectors in country U (average of $C_{kk',U}$ over sectors). The exercise considers high trade costs in the service sector ($d_{k,oi} = 2$) and the same aggregate productivity parameter ($A_{k,o} = 1$) in all countries and sectors. The solid blue line presents relative welfare for country U (VF_U^T / VF_U^{T0}) while the dashed red line presents the equivalent measure for country C. The dotted yellow line shows relative welfare values between the two countries at time T. Figures 2b, 2c and 2d present similar analysis considering other parameters in country U: ζ_U, m_U and (average of) $b_{k,U}$, respectively.

Note that more "fluid" labor markets (implied by lower moving costs or higher

[18]More precisely, I use the correctly adjusted labor mobility friction parameters, $C_{kk',i}$ and ζ_i, estimated for the USA in Section 3, as well as the trade elasticity λ later estimated in the paper. The other labor market parameters are calibrated such that i) the unemployment rate in each sector is equal to the overall USA unemployment rate in 2005; ii) labor force allocated to each sector is the one observed in the USA in 2005.

Figure 2: Trade Cost Shock - Steady State Changes by Country



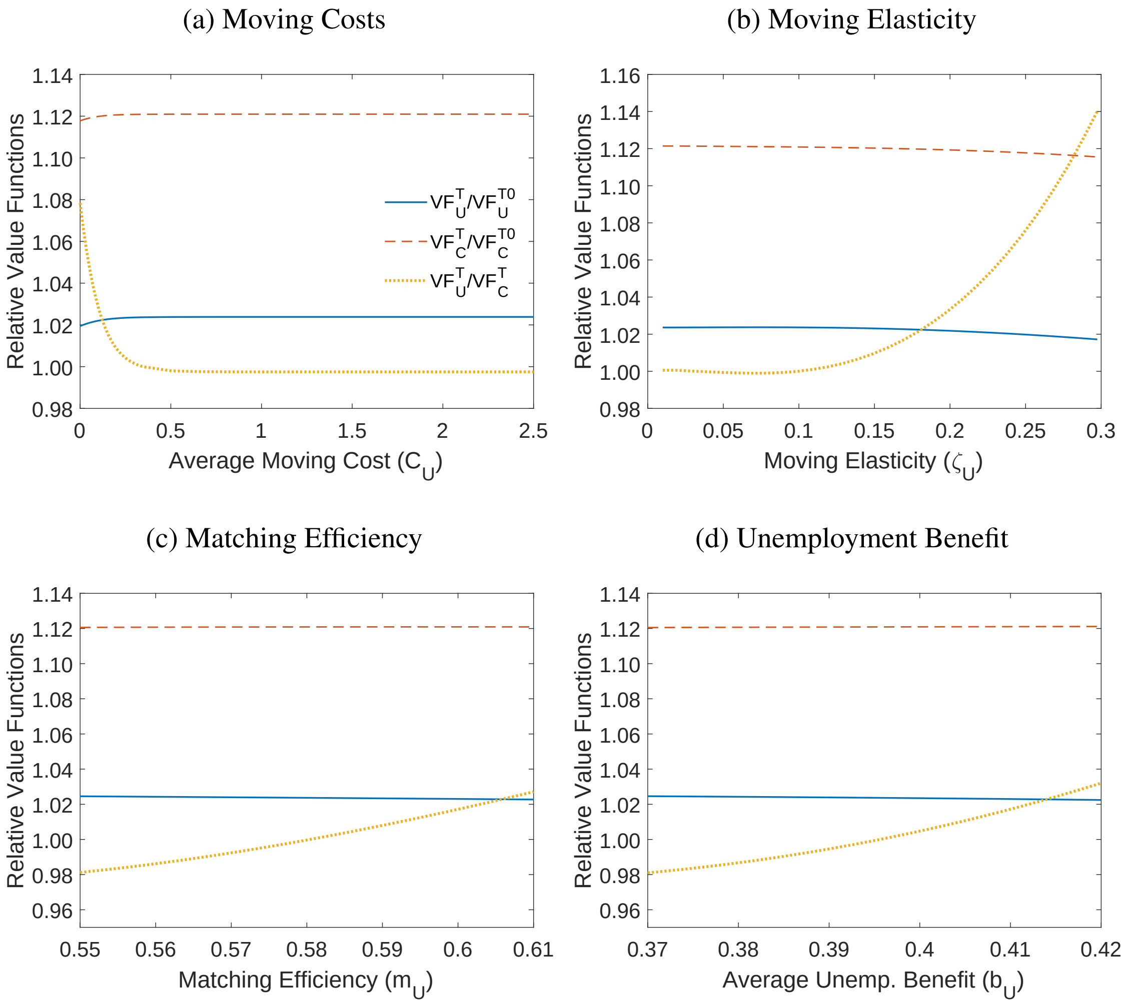
NOTES: Figures show relative welfare values across steady states after trade costs fall from $d_{k,CU} = d_{k,UC} = 1.05$ at time $T0$ to $d_{k,CU} = d_{k,UC} = 1$ at time T in the agricultural and manufacturing sectors in both countries for different values of parameters in country U. The solid line presents relative welfare for country U, while the dashed line presents the equivalent measure for country C. The yellow dotted line shows relative welfare values between the two countries at time T. The service sector has high trade costs ($d_{k,CU} = d_{k,UC} = 2$) and all countries/sectors have the same aggregate productivity parameter ($A_{k,o} = 1$). The panels consider this exercise for distinct values of four parameters of country U. Panel (a) average of $C_{kk',U}$ over sectors; Panel (b) ζ_U; Panel (c) m_U; Panel (d) average of $b_{k,U}$ over sectors.

matching efficiency) increase the value of welfare in country U relative to that of country C. The same effect takes place almost mechanically after a rise in the variance of idiosyncratic shocks or unemployment benefits, as both increase workers' discounted utility directly.[19] However, relative welfare gains from the trade shock are lower in country U than in country C. This suggests that countries with more rigid labor markets (and lower welfare) tend to gain more from trade than countries with more efficient labor

[19]Note that a rise in ζ_i would not only increase value functions mechanically, but also diminish responsiveness of workers to expected income differentials across sectors, and hence, it could increase labor market rigidity and decrease VF^T_U/VF^T_C. However, the first effect seems to be the dominant one.

markets (and higher welfare).[20]

Figure 3: Productivity Shock - Steady State Changes by Country



NOTES: Figures show relative welfare values across steady states after productivity rises from $A_{k,C} = 0.95$ at time $T0$ to $A_{k,C} = 1$ at time T in the agricultural and manufacturing sectors in country C for different values of parameters in country U. The solid line presents relative welfare for country U, while the dashed line presents the equivalent measure for country C. The yellow dotted line shows relative welfare values between the two countries at time T. The service sector has high trade costs ($d_{k,CU} = d_{k,UC} = 2$) and the other sectors have free trade ($d_{k,CU} = d_{k,UC} = 1$). All countries/sectors have the same aggregate productivity parameter ($A_{k,o} = 1$) at time T. The panels consider this exercise for distinct values of four parameters of country U. Panel (a) average of $C_{kk',U}$ over sectors; Panel (b) ζ_U; Panel (c) m_U; Panel (d) average of $b_{k,U}$ over sectors.

Figure 3 presents a similar exercise considering a rise in productivity from $A_{k,C} = 0.95$ at time $T0$ to $A_{k,C} = 1$ at time T in the agricultural and manufacturing sectors in country C. The qualitative results are similar to the ones shown in Figure 2. The magnitudes, however, are quite different: country C presents considerably higher welfare gains than country U. This is evidence that (asymmetric) productivity shifts generate

[20]My results are similar to the ones found in Helpman and Itskhoki (2010), where the authors show (analytically) that countries gain from trade independently of differences in labor market rigidities.

remarkably unequal gains across countries.

Figures 9 and 10 show the effect of the two previous exercises on real income. The effects are less pronounced but not qualitatively different from the welfare ones considering a fall in trade costs. Interestingly, a rise in productivity in country C produces a fall in real income in country U. After relative wages change following the productivity rise in country C, workers move towards the services sector, which has the lowest paid jobs (on average). Hence, overall income falls due to this reallocation effect, despite the fact that average wages rise and unemployment rates fall in all sectors in country U after the shock.

The model also delivers interesting dynamic implications that are deeper investigated in my full numerical exercise performed in Section 4.

3 Estimation

In this section, I estimate a sub-set of the parameters of the model. I start by estimating the trade elasticity (λ) and and the productivity parameter that drives absolute and comparative advantages ($A_{k,i}$) using bilateral trade flows. Then, I proceed to estimate the variance of the idiosyncratic labor mobility shocks, ζ_i, and the fixed moving costs, $C_{kk',i}$. All the other parameters will be calibrated.

3.1 Trade Parameters

The trade elasticity λ is estimated using a gravity equation. By taking logs of expression 18, I obtain the following relationship:

$$ln(X^t_{k,oi}) = \lambda ln(A_{k,o}) + ln(X^t_{k,i}/\Phi^t_{k,i}) - \lambda ln(\tilde{w}^t_{k,o}) - \lambda ln(d_{k,oi}).$$

I follow Costinot, Donaldson, and Komunjer (2012) closely in my estimation. First, I account for the endogenous selection of varieties that are actually produced domestically by substituting for $X^t_{k,oi}$ using $\tilde{X}^t_{k,oi} \equiv X^t_{k,oi}/\pi^t_{k,oo}$. Second, I consider one reference country and one reference sector. Third, I use a double difference version of the gravity equation:

$$ln(\frac{\tilde{X}^t_{k,oi}\tilde{X}^t_{k',o'i}}{\tilde{X}^t_{k',oi}\tilde{X}^t_{k,o'i}}) = \lambda ln(\frac{A_{k,o}A_{k',o'}}{A_{k',o}A_{k,o'}}) - \lambda ln(\frac{\tilde{w}^t_{k,o}\tilde{w}^t_{k',o'}}{\tilde{w}^t_{k',o}\tilde{w}^t_{k,o'}}) - \lambda ln(\frac{d_{k,oi}d_{k',o'i}}{d_{k',oi}d_{k,o'i}}).$$

Even though it is possible to take the above equation to the data, Costinot, Donaldson, and Komunjer (2012) claim that is simpler and closer to the literature to estimate the econometrically equivalent specification:

$$ln(\tilde{X}^t_{k,oi}) = \lambda ln(A_{k,o}) - \lambda ln(\tilde{w}^t_{k,o}) + \chi^t_{oi} + \chi^t_{k,i} + \bar{\varepsilon}^t_{oi,k}, \tag{23}$$

where χ^t_{oi} is an importer-exporter fixed effect, $\chi^t_{k,i}$ is an importer-sector fixed effect, and $\bar{\varepsilon}^t_{oi,k}$ captures (part of) the variation in trade costs and measurement errors in trade flows. λ will be estimated as the coefficient of $A_{k,o}$ in 23.

3.1.1 Data

First, I obtain bilateral trade flows from the World Input Output Database (WIOD).[21] As in Costinot, Donaldson, and Komunjer (2012), I measure the variation in productivity across countries and industries using differences in producer price indexes. Producer price data is taken from the GGDC Productivity Level Database, which is calculated from raw price data observations at the plant level for several thousand products (often with hundreds of products per industry, which can be associated with varieties in my model).[22] These prices are aggregated into a producer price index at the industry level using output data. I use the inverse of this measure as $A_{k,o}$ to identify the trade elasticity in the gravity equation. My estimate of λ will also allow me to obtain a more precise measure of $A_{k,o}$ (as I explain later in this sub-section).

In order to obtain λ, I base my estimations on the year 2005, and 1997 lags are used as instruments for my productivity parameter $A_{k,o}$ (GGDC data is available only for these two years). I consider 40 countries available in the WIOD database (excluding the "Rest of the World", which is a tiny fraction of the global trade volume). I also aggregate the economy into five sectors:[23]

-*Energy and Others*: Energy, Mining and quarrying; Agriculture, Forestry and fishing;

[21] See Stehrer, de Vries, Los, Dietzenbacher, and Timmer (2014) for more details on this database.

[22] See Inklaar and Timmer (2008) for more details.

[23] Aggregating the economy into fewer sectors is not necessary for estimation, but the algorithm I use to find an equilibrium works considerably better when the number of sectors is not very large, and hence, I keep a reduced number of sectors in my algorithm and in my estimation. Increasing the number of sectors does not change the estimation results substantially.

-*Low-Tech Manufacturing*: Wood products; Paper, printing and publishing; Coke and refined petroleum; Basic and fabricated metals; Other manufacturing.

-*Mid-Tech Manufacturing*: Food, beverage and tobacco; Textiles; Leather and footwear; Rubber and plastics; Non-metallic mineral products.

-*High-Tech Manufacturing*: Chemical products; Machinery; Electrical and optical equipment; Transport equipment.

-*Services*: Utilities; Construction; Sale, maintenance and repair of motor vehicles and motorcycles; Retail sale of fuel; Wholesale trade; Retail trade; Hotels and restaurants; Land transport; Water transport; Air transport; Other transport services; Post and telecommunications; Financial, real estate and business services; Government, education, health and other services; Households with employed persons.

The manufacturing rank of technology is based on R&D intensity in the USA in 2005 from OECD STAN database.

I do not observe $\tilde{w}_o^k$. In order to control for the last two terms of the gravity equation and still be able to identify λ as the coefficient of $A_{k,o}$, I replace their values by a 4^{th} degree polynomial function of variables related to labor costs for each exporter-sector pair: Labor compensation per employee, labor compensation per hour and labor compensation share of value added. Information on labor markets characteristics by sector and country comes from the WIOD Socio Economic Accounts database.

3.1.2 Estimates

Table 1 presents the estimates of λ using Equation 23. Columns 1 and 2 are estimated by OLS, while columns 3 and 4 are estimated by 2SLS (using 1997 values as instruments). Controlling for labor cost proxies (columns 2 and 4) decreases the coefficient, while using lagged productivity values as instruments increases it considerably. I use the value of 4.172 in my counterfactuals, which is not far from Costinot, Donaldson, and Komunjer (2012) estimates.

As in Costinot, Donaldson, and Komunjer (2012), I do not use the GGDC database to compute the values of $A_{k,o}$ that will be used in my analysis. I will use a "revealed productivity" measure obtained in the following way. By using the WIOD data from 2000 up to 2005, I am able to run the following variation of the gravity equation

Table 1: Estimates of λ

	(1) OLS	(2) OLS	(3) 2SLS	(4) 2SLS
	Log of Exports (adjusted)			
λ	1.877***	1.394**	4.414***	4.172***
	(0.656)	(0.668)	(1.489)	(1.400)
KP F-Stat (1^{st} Stage)			28	26
$N_{clusters}$	152	152	120	120
Observations	5920	5920	4674	4674
Importer-exporter F.E.	Yes	Yes	Yes	Yes
Importer-sector F.E.	Yes	Yes	Yes	Yes
Labor Cost	No	Yes	No	Yes

NOTES: λ is the coefficient of the productivity measure $A_{k,o}$ in Equation 23, which uses bilateral trade flows at the sector level as the dependent variable and fixed effects for importer-sector and exporter-importer fixed effects. Data is a cross-section of bilateral trade data in 2005, obtained from WIOD and GGDC data sets. Labor Cost is a $4^t h$ degree polynomial function of labor compensation per employee, labor compensation per hour and labor compensation share of value added. Columns 3 and 4 have the lag of $A_{k,o}$ (1997 value) as instrument. Clustered standard errors at the exporter-industry level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

$$ln(\tilde{X}^t_{k,oi}) = \chi^{t_0}_{k,o} + t * \chi_{k,o} - \lambda ln(\tilde{w}^t_{k,o}) + \chi^t_{oi} + \chi^t_{k,i} + \bar{\varepsilon}^t_{oi,k}. \tag{24}$$

I substitute for $\lambda ln(A_{k,o})$ using an exporter-sector fixed effect at time t_0 and assume that productivity evolves over time according to an exporter-sector specific linear trend $(\chi^{t_0}_{k,o} + t * \chi_{k,o})$. And with the estimate of λ from Table 1, I am able recover $A_{k,o}$ at time t as $exp[(\chi^{t_0}_{k,o} + t * \chi_{k,o})/\lambda]$. The values of $A_{k,o}$ for the years 2000 and 2005 and for the final aggregation of countries used in my counterfactuals are shown in Table 10 in the appendix.[24] Note that I have to choose one reference country and sector in my estimation equation. I choose the USA and the agricultural sector, and hence, they have their productivity measures equal to 1.

3.2 Labor Market Parameters

I estimate the costs of switching industries to workers by building on the methodology developed by Artuç (2013) and Artuç and McLaren (2015). These labor market parameters are estimated only for the USA and used for all other countries in my counterfactuals. Naturally, it would be more accurate to estimate the parameters for all the countries con-

[24]More details about the final group of countries used in my numerical exercises can be found in Subsection 3.3. I used value added by country-sector to aggregate the estimated values of $A_{k,o}$.

sidered in the next sub-section, and I recognize that this approximation may be unsuitable especially for economies that are very distinct, but data restrictions do not allow me to follow this route and I believe that applying USA parameters to other countries can still provide important qualitative insights for adjustment dynamics. Estimating these parameters for other countries is an important topic for future work but is beyond the scope of this paper.

I conduct the estimation in three stages. First, the probability of finding a job in a sector and actually start producing, $\theta^t_{k,i}q(\theta^t_{k,i})\ (1-G(R^{t+1}_{k,i}))$, will be estimated non-parametrically in a first stage by computing the number of individuals that were looking for a job in a sector and succeeded divided by the total number of individuals looking for a job in the sector (see Sub-section 3.2.1 for more details on how this variable is computed). Second, I rewrite Equation 13 as

$$S^t_{kk',i} = exp(D^t_{k',i} - O^t_{k,i} - \frac{C_{kk',i}}{\zeta_i}) + \varepsilon^t_{kk',i}, \tag{25}$$

where $S^t_{kk',i} \equiv s^t_{kk',i}L^t_{k,i}u^t_{k,i}$ is the total number of unemployed workers switching between sectors k and k', and $D^t_{k',i}$ and $O^t_{k,i}$ are destination and origin fixed effects, respectively, equal to:

$$D^t_{k',i} = \frac{U^{t+1}_{k',i}}{(1+r)\zeta_i} - \frac{U^{t+1}_{o,i}}{(1+r)\zeta_i}, \tag{26}$$

$$O^t_{k,i} = log(L^t_{k,i}u^t_{k,i}) - D^t_{k,i} - \frac{\Omega^t_{k,i}}{\zeta_i}, \tag{27}$$

and $\varepsilon^t_{kk',i}$ is an error term. My second stage consists on regressing the number of individuals switching sectors on destination-time and origin-time fixed effects and $C_{kk',i}/\zeta_i$, which is modeled as a fixed entry cost, i.e., $C_{kk',i}$ is a positive constant if $k \neq k'$ and zero otherwise. Note that o is a reference sector, which will be equivalent to the omitted sector in my estimation regression.

In my third stage, I rewrite the unemployment value Equation 4 in the following way:

$$E^t_{k,i} = \iota^t_i + \frac{1}{(1+r)^2\zeta_i}(b_{k,i}+\eta_{k,i}) + \frac{1}{(1+r)^2\zeta_i}[\theta^t_{k,i}q(\theta^t_{k,i})(1-G(R^{t+1}_{k,i}))(\bar{w}^{t+1}_{k,i} - w^{t+1}_{k,i}(R^{t+1}_{k,i}))] + \bar{\varepsilon}^t_{k,i}, \tag{28}$$

where

$$E^t_{k,i} \equiv D^{t-1}_{k,i} - \frac{1}{1+r}\left(\theta^t_{k,i}q(\theta^t_{k,i})(1-G(R^{t+1}_{k,i}))D^t_{k,i}\right) + \frac{1}{1+r}\left([1-\theta^t_{k,i}q(\theta^t_{k,i})(1-G(R^{t+1}_{k,i}))](O^t_{k,i} - log(L^t_{k,i}u^t_{k,i}))\right),$$

$\iota^t_i = U^{t+1}_{o,i}/(1+r)\zeta_i - U^t_{o,i}/(1+r)\zeta_i$, and $\bar{\varepsilon}^t_{k,i}$ is another error term (see Appendix B.3 for details of the derivations). Equation 28 equates $E^t_{k,i}$ (which depends on observables and estimates obtained in the previous stages) to a time dummy (ι^t_i), plus unemployment benefit, workers' average preferences and the probability of finding a job and start producing at $t+1$ multiplied by the expected wage ($\bar{w}^{t+1}_{k,i}$) discounted by the minimum wage ($w^{t+1}_{k,i}(R^{t+1}_{k,i})$) in sector k, both observable in the data.

In sum, in my third stage I estimate 28 using the two first stage estimates and information on wages of individuals in a sector to obtain $1/\zeta_i$ as the coefficient of

$\frac{1}{(1+r)^2}[\theta^t_{k,i}q(\theta^t_{k,i})(1-G(R^{t+1}_{k,i}))(\bar{w}^{t+1}_{k,i} - w^{t+1}_{k,i}(R^{t+1}_{k,i}))]$.

With ζ_i, I can then recover the entry costs $C_{k',i}$'s from my second stage estimates. Note that I cannot separately identify $b_{k,i}$ and $\eta_{k,i}$. Hence, I simply replace $b_{k,i}+\eta_{k,i}$ by a sector dummy and a sector time trend and leave these parameters to be calibrated later (together with $b_{k,i}$'s and $\eta_{k,i}$'s for other countries).

3.2.1 Data

I use the "March Supplement" of the Current Population Survey (CPS), downloaded from the Integrated Public Use Microdata Series (IPUMS) website.[25] It contains basic monthly demographic and labor force data. My analysis considers workers between 25

[25]The technical name for this supplement since 2003 is the Annual Social and Economic Supplement (ASEC) or the Annual Demographic File (ADF) between 1947 and 2003.

and 65 years of age, and the same five industries described previously: Services, Energy and Others, Low-Tech, Mid-Tech and High-Tech Manufacturing. My period of analysis goes from 1983 to 2002.[26]

To calculate workers annual earnings, I use information on each respondent's total pre-tax wage and salary income for the previous calendar year. $\bar{w}^{t-1}_{k,i}$ will be the average of this variable in year t (using the appropriate CPS weights). All variables are adjusted to real 1999 USD using the CPI-U provided by IPUMS. I also normalize the average real wage in the sample to 1. To account for possible outliers in the data, I calculate $w^t_{k,i}(R^t_{k,i})$ as the the 5^{th} or the 1^{st} percentiles of wages in an industry-year pair and verify the robustness of my estimations to both specifications.

In my model, $OF^t_{k,i}$ is the total number of unemployed individuals who chose to move (or not) from sector k at time t. My dependent variable in the second stage, $S^t_{kk',i}$, will be the sub-set of $OF^t_{k,i}$ who are associated with sector k at time t and are in sector k' at time $t+1$ (employed or not).

To obtain my second stage dependent variable, I use CPS information on workers' current and previous (year) industry of work (and occupation), as well as information on whether a worker spent some time unemployed in the previous year. I assume that $OF^t_{k,i}$ (and $IF^t_{k,i}$) includes workers who were unemployed or potentially switched jobs in my sample (within or across industries), i.e., it includes all individuals who switched industries or occupations (employed or not at time $t+1$), as well as individuals who spent at least some time unemployed in period t. Implicitly, I am considering that individuals who switched jobs between periods spent at least a small fraction of time unemployed before choosing a new position in a (potentially different) sector.

Proceeding in a similar fashion, I can calculate the actual job finding rate, $\theta^t_{k,i}q(\theta^t_{k,i})(1-G(R^{t+1}_{k,i}))$. First I find $IF^{t-1}_{k,i}$, and the actual job finding rate will be equal to the share of $IF^{t-1}_{k,i}$ that is employed at time t.

I provide summary statistics for some variables used in my estimation in Appendix B.4. Table 6 shows that wages and job finding rates differ across industries and are positively correlated. Table 7 presents the average (over time) share of workers that move across sectors (row origin and column destination). The greatest share of of movers stay in their industries of origin. As expected, workers appear to be more mobile across

[26]The correspondence of industries between the WIOD and the CPS data sets (and across years within the CPS) was constructed using tables available on the National Bureau of Economic Research (NBER) website.

industries in my sub-sample when compared to a case that include all non-job switchers (Artuç, Chaudhuri, and McLaren, 2010).

3.2.2 Estimates

Table 2 presents my second stage estimates (Equation 25) of $-C_{k',i}/\zeta_i$ for the USA. Column 1 was estimated by OLS (after taking logs of the estimating equation). Following Artuç and McLaren (2015), I also present estimates using the PPML estimator from Santos-Silva and Tenreyro (2006) in column 2, which will be my preferred specification. Table 2 shows that Agriculture is the sector with the highest entry cost. It is more than three times the entry cost of the services sector, which possesses the lowest value across all sectors.

Table 2: Second Stage Estimates

	(1) OLS	(2) PPML
	$-C_{k',i}/\zeta_i$	
Agriculture and Others	-4.231***	-3.484***
	(0.139)	(0.077)
Low-tech Manuf.	-1.882***	-1.769***
	(0.139)	(0.111)
Mid-tech Manuf.	-2.729***	-2.726***
	(0.139)	(0.113)
High-tech Manuf.	-2.311***	-2.390***
	(0.139)	(0.110)
Services	-1.235***	-1.421***
	(0.139)	(0.067)
Observations	499	499

NOTES: Values of entry costs per sector, $-C_{k',i}/\zeta_i$, for USA workers obtained from estimating Equation 25. Column 1 estimated by OLS (after taking logs of the estimating equation). Column 2 estimated using the PPML estimator from Santos-Silva and Tenreyro (2006). Data is the CPS "March Supplement", obtained from IPUMS. Sample of workers between 25 and 65 years of age for the period 1983-2002, aggregated up to the industry level. Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Remember that I also obtain $D^t_{k',i}$ and $O^t_{k,i}$ from my second stage estimates (not shown here). This will allow me to obtain ζ_i from my third stage estimates (see Equation 28).

Table 3 presents the estimates of $1/\zeta_i$. Panel A presents estimations in levels of Equation 28 and panel B presents the first difference estimates (without industry-time trends). Columns 1 and 2 use the first wage percentile at time t, while columns 3 and 4 consider the fifth. Columns 1 and 3 show my OLS estimates, while columns 2 and 4 present 2SLS results using the lag of $\frac{1}{(1+r)^2}[\theta^t_{k,i}q(\theta^t_{k,i})(1-G(R^{t+1}_{k,i}))(\bar{w}^{t+1}_{k,i}-w^{t+1}_{k,i}(R^{t+1}_{k,i}))]$ as an instrument.[27]

The OLS estimates in panels A and B are similar. The 2SLS results, however, are quite different. The instrument is very weak (as shown by the Kleibergen Paap F-stat) and the coefficients become statistically insignificant in columns 2 and 4 of panel A, while in panel B the instrument is strong and the coefficients are significant. My preferred specification (column 4 of panel B) implies $\zeta_i = 0.2$, a value considerably lower than the ones presented in Artuç, Chaudhuri, and McLaren (2010). This means that workers are more responsive to expected income differentials across sectors. This is not surprising given that I am focusing on workers who potentially moved jobs across periods.

Table 3: Third Stage Estimates

	(1) OLS	(2) 2SLS	(3) OLS	(4) 2SLS
Panel A		**Levels**		
$1/\zeta_i$	5.826***	0.746	5.946***	0.858
	(1.038)	(7.185)	(0.873)	(8.385)
KP F-stat		1		1
Observations	90	90	90	90
Industry-time Trend	Yes	Yes	Yes	Yes
Panel B		**First Differences**		
$1/\zeta_i$	5.634***	5.390*	5.641***	4.960**
	(1.454)	(3.008)	(1.078)	(2.468)
KP F-stat		15		16
Observations	85	85	85	85
Industry-time Trend	No	No	No	No
Industry Fixed-effect	Yes	Yes	Yes	Yes
Wage Percentile	1^{st}	1^{st}	5^{th}	5^{th}

NOTES: Values of entry costs per sector, $1/\zeta_i$, for USA workers obtained from estimating Equation 28. Panel A presents estimations in levels of the equation, while panel B presents estimations in first differences. Columns 1 and 3 estimated by OLS and columns 3 and 4 estimated 2SLS results using the lag of $\frac{1}{(1+r)^2}[\theta^t_{k,i}q(\theta^t_{k,i})(1-G(R^{t+1}_{k,i}))(\bar{w}^{t+1}_{k,i}-w^{t+1}_{k,i}(R^{t+1}_{k,i}))]$ as an instrument. Data is the CPS "March Supplement", obtained from IPUMS. Sample of workers between 25 and 65 years of age for the period 1983-2002, aggregated up to the industry level. $\bar{w}^t_{k,i}$ is equal to the average of workers annual earnings (total pre-tax wage and salary income) in year t (using the appropriate CPS weights). All variables are adjusted to real 1999 USD using the CPI-U provided by IPUMS. The average real wage in the sample is normalized to 1. To account for possible outliers in the data, I calculate $w^t_{k,i}(R^t_{k,i}))$ as the the 1^{st} (columns 1 and 2) or the 5^{th} (columns 3 and 4) percentiles of wages in an industry-year pair. Robust standard errors in parentheses. $^* p < 0.10$, $^{**} p < 0.05$, $^{***} p < 0.01$.

[27] Artuç, Chaudhuri, and McLaren (2010) follow a similar instrumental variable strategy.

3.3 Other Parameters

I calibrate the remaining parameters of the model. In order to do so, I first assume the following constant returns to scale matching function:

$$m(v_{k,i}^t, u_{k,i}^t) = m_i (u_{k,i}^t)^{1-\delta} (v_{k,i}^t)^{\delta},$$

where m_i is a country specific matching efficiency, and δ is a matching elasticity parameter common to all countries in my model.

Second, I assume that idiosyncratic productivity shocks are uniformly distributed between zero and one (Ranjan, 2012). This assumption was not necessary for my previous estimates. To verify the robustness of my counterfactuals to this and other assumptions I perform additional counterfactual exercises with alternative parameter values.

Third, I reduce the number of countries to six due to computational reasons. The "countries" chosen are China, USA, UK, European Union (EU), the Rest of the World (RoW) Developed and the RoW Developing. The last economies are an aggregation of the remaining WIOD countries, which were separated in high-income (Australia, Japan, Canada, South Korea and Taiwan) and low-income countries (Brazil, India, Indonesia, Mexico, Turkey and Russia).

Finally, by using the WIOD and WIOD - Socio Economic Accounts databases, together with unemployment data by country from the Bureau of Labor Statistics (for the USA) and from the International Labour Organization (for the remaining countries),[28] I am able to find the parameters that match moments from the model to their data counterparts (I aggregate countries and sectors using value added as weights). I set trade imbalances per country to zero ($\xi_o = 0$) and match trade shares ($\pi_{k,oi}$), expenditure shares ($\mu_{k,o}$), unemployment rates ($u_{k,o}$, assuming they are equal across sectors within a country), and total production values ($Y_{k,o}^t$) and labor force ($L_{k,o}^t$) per country-sector pairs to their observed values in 2005. This will allow me to find δ, m_i, $b_{k,i}$, $\beta_{k,o}$, $\mu_{k,o}$ and $d_{k,oi}$. $\kappa_{k,i}$ and $\eta_{k,i}$ are then obtained as residuals such that the modified unemployment value equation (38) and the job destruction condition (34) hold in the initial steady state. The correlation between the moments in the model and in the data are generally high (between 94% and 99%). The calibrated parameters are shown in Tables 11 and 12 in the

[28] Available at https://www.bls.gov/cps/cps_aa2005.htm and http://www.ilo.org/ilostat.

appendix (and $\delta = 0.305$).[29]

Note that the parameters ζ_i and $C_{k',i}$ used in the counterfactuals are held as fixed proportion of average income per capita in a country. For example, if average income is equal to 10 in equilibrium in the UK, ζ_i will be equal to 10 times my estimated value of ζ_i in the initial equilibrium (and then kept fixed). This implies that different countries will have different values for these parameters, but all countries will have the same levels of labor market frictions. The summary of all the parameters are shown in Table 13.

4 Counterfactuals and Simulations

The counterfactuals performed are meant to understand how the rise of China affected other countries in the world, especially the USA and the UK. The trade shock I have in mind is one whereby Chinese productivity increases ($A_{k,CHN}$) and all trade costs between China and the rest of the world fall ($d_{k,oCHN}$ and $d_{k,CHNi}$) in all sectors apart from services. This shock implies that China's trade volume (exports plus imports) around the world approximately triples between the two steady states. This is approximately equal to the growth of Chinese trade volume between 2000 (the year before China joined the WTO) and 2005 in the WIOD data.[30] So, my shock aims to mimic the five year period following China's entry into the WTO in terms of percentage change in the its trade volume. I study how countries respond to this shock during the transition to a new steady state.

Details about the method used to compute the initial steady state and transition paths can be found in Appendices B.1 and B.2. The objective is to find a rational expectations path between the initial and the final steady state. For the transition, I use a type of mul-

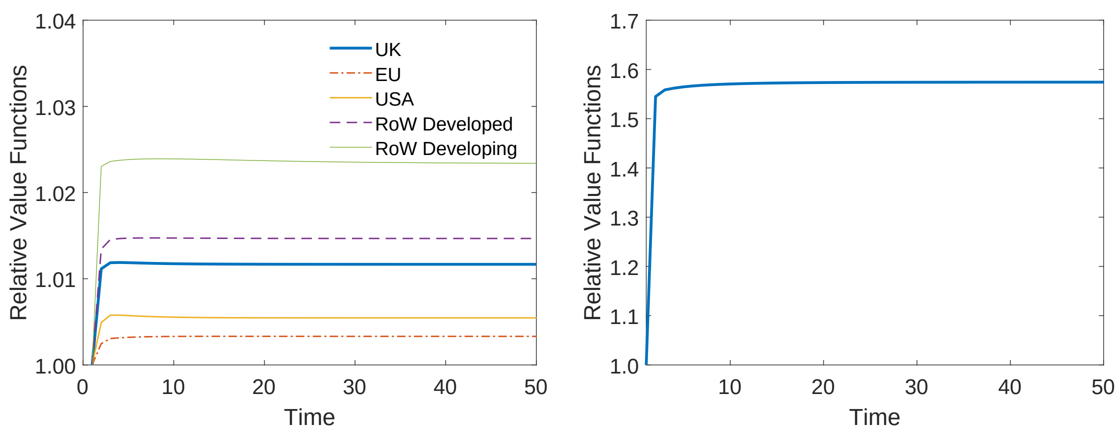
[29]The productivity parameters $A_{k,o}$ do not take into account, for example, that the UK produces higher quality goods such as air-planes and more advanced cars. Thus, my trade cost calibration implies that I am actually finding an additional parameter that *includes* trade costs such that trade shares are as close as possible to the values observed in the WIOD in 2005. Put another way, I substitute for $d_{k,oi}$ (the iceberg trade cost described previously) in all my expressions using $\bar{d}_{k,oi} = d_{k,oi} * \omega_{k,oi}$, where $\omega_{k,oi}$ is an unobserved component that accounts, for example, for quality difference across countries. Then, I calibrate the $\bar{d}_{k,oi}$'s such that trade shares are as close as possible to the ones observed in the data (assuming $\bar{d}_{k,oo} = 1$ for all countries). The fact that trade costs are not identified does not play a large role in my counterfactuals, since I am interested in their relative changes (and also in relative income changes).

[30]More precisely, Chinese import and export growth are equal to 212% and 171% in the data, while in the model they are equal to 212% and 202%, respectively. To obtain these changes, I assume that Chinese productivity ($A_{k,CHN}$) rises by approximately 9.8% (the average growth in Chinese revealed productivity obtained from the data - see Table 10), and that import and export costs ($d_{k,oCHN}$ and $d_{k,CHNi}$) fall by 31.6% and 33%, respectively, in all sectors apart from Services.

tiple shooting algorithm that builds on Artuç, Chaudhuri, and McLaren (2010), Artuç, Chaudhuri, and McLaren (2008) and Lipton, Poterba, Sachs, and Summers (1982). In my algorithm I have to assume a certain number of years for the transition period to occur.[31] I consider 89 years in my numerical exercises, but the higher the number of years assumed the closer the variables of the system are to their new steady state values in the final period of the algorithm. In my numerical simulations more than 99% of the adjustment has taken place in year 89 (and most variables have already converged in year 50).

4.1 Results

Figure 4: Welfare



NOTES: Transition paths of real value functions per country relative to the initial steady state equilibrium following an unanticipated increase in Chinese productivity ($A_{k,CHN}$) of 9.8% and a fall in Chinese import and export costs ($d_{k,oCHN}$ and $d_{k,CHNi}$) of 31.6% and 33%, respectively, in all sectors apart from Services.
EU: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Greece, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Portugal, Poland, Romania, Slovak Republic, Slovenia, Spain and Sweden.
RoW Developed: Australia, Canada, Japan, Korea (south) and Taiwan.
RoW Developing: Brazil, India, Indonesia, Mexico, Russia and Turkey.

Figure 4 shows the evolution of countries' weighted discounted utilities over the years following the fall in trade costs and productivity gains in China. One can see that welfare instantly increases in all regions. Not only countries are able to export more to China and consumers have access to cheaper goods, but also workers' option values increase. As emphasized by Artuç, Chaudhuri, and McLaren (2010), better conditions (employment

[31]Such types of non-linear systems of equations can only be guaranteed to converge asymptotically - see Lipton, Poterba, Sachs, and Summers (1982).

and/or wages) in *some* sectors benefit workers in *all* sectors. Chinese citizens experience large welfare gains of more than 57% (see Figure 4b).[32]

Figure 11 in the appendix shows that most countries other than China do not observe a significant change in their real income levels in the short-run, and basically no change in the long-run.[33] This is evidence that welfare gains arise because employment conditions are improving in relatively richer sectors, i.e., workers are moving towards sectors with higher baseline wages (aggregate employment levels increase in all countries, as shown by Figure 12 in the appendix).[34]

Some countries, such as the USA and the UK, experience an initial overshooting in welfare. One reason behind this is that after the shock wages (and prices) do the majority of the "heavy-lifting" in the short-run to keep markets cleared, as production is rigid (especially upwards) because it takes time for jobs to be created due to the search and matching frictions in the labor market and for workers to move across sectors due to the fixed moving costs. Immediately after the shock, wages rise in the exporting sectors and fall in the ones facing fierce import competition from China. Hence, the overshooting of wages accruing to workers in the USA and in the UK (together with the fact that consumers have access to cheaper goods) excessively benefits these countries in the short-run. Other regions such as the EU exhibit an initial jump in welfare and then experience a mild welfare increase. This is so because the overshooting of wages accruing to workers is mild or non-existent, generating gains that can be lower in the short-run.[35]

Countries experience different levels of welfare changes. These levels depend on how the shock changes comparative (and absolute) advantages around the globe and on

[32]Considering a different time period, di Giovanni, Levchenko, and Zhang (2014) find that the welfare impacts of the rise of China on other countries range from 0.8% to -0.27 %. Caliendo, Dvorkin, and Parro (2017) find welfare gains of 0.35% for the USA considering the 2000-2007 period.

[33]The exception is the RoW developing, a region that experiences a significant rise in real income in the short-run. This is due to the fact that the agricultural sector is large in the baseline period and gets larger after the shock. Hence, overshooting of wages in the short-run benefit a significant share of workers in the first years after the shock, leading to a steep rise in consumption. On the other hand, workers in the agricultural sector earn lower wages on average. As workers move towards this sector, overall consumption falls.

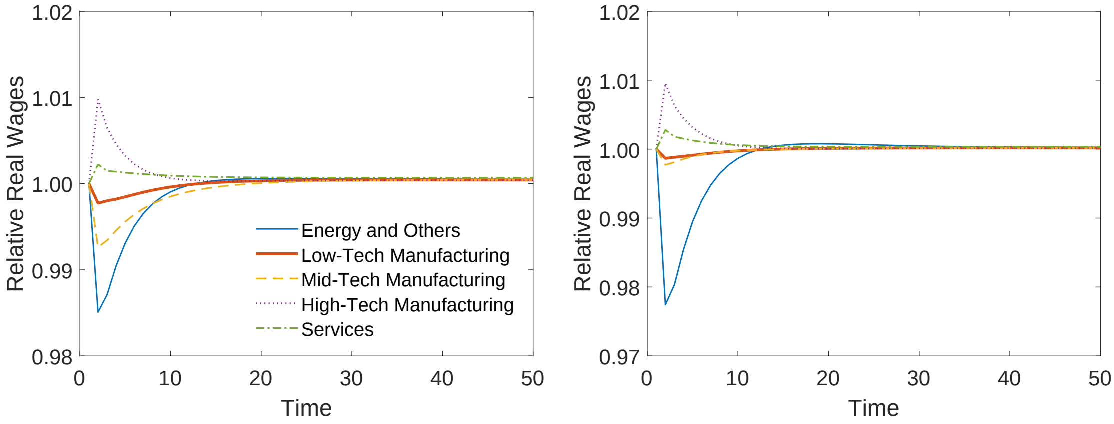
[34]Despite the observed employment gains following the rise of China, the impact of trade integration on aggregate employment levels is ambiguous in my model. Helpman, Itskhoki, and Redding (2010) and Helpman and Itskhoki (2010) also show an ambiguous relationship between employment and trade openness.

[35]Itskhoki and Helpman (2014) carefully characterize the transition period following a trade shock with imperfect labor markets. They also show that countries gain in the short-run because benefits from trade arise instantaneously after a fall in trade costs.

countries' consumption share ($\mu_{k,i}$ in the model) in each sector. For example, after the shock, China's productivity advantage tend to increase for manufacturing goods, especially in Low-Tech and Mid-Tech Manufacturing. This implies that China will be able to export more goods at cheaper prices. If a country has a significant amount of resources allocated to the production of Low-Tech and Mid-Tech Manufacturing products in the initial equilibrium, it will be hurt more severely by China.

Figure 5: Relative Real Wage per Sector in the UK and in the USA

(a) UK (b) USA

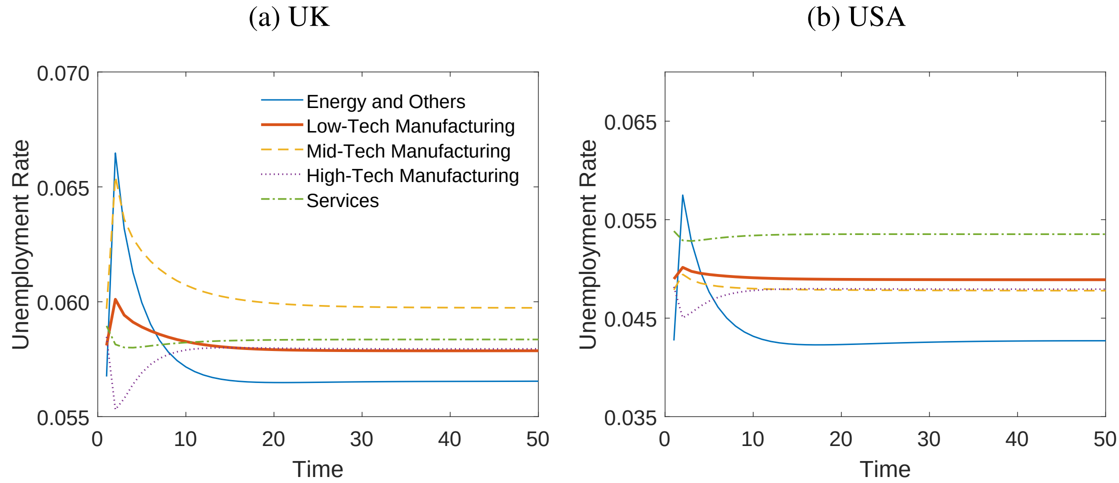


NOTES: Transition paths of UK and USA real wages per sector relative to the initial steady state equilibrium following an unanticipated increase in Chinese productivity ($A_{k,CHN}$) of 9.8% and a fall in Chinese import and export costs ($d_{k,oCHN}$ and $d_{k,CHNi}$) of 31.6% and 33%, respectively, in all sectors apart from Services. Legend in panel (a) is valid for both panels.

The effects are not only heterogeneous across countries but also across sectors within countries, as shown in Figure 5, which plots the adjustment in real wages by sector in the UK and in the USA. The Low-Tech and Mid-Tech Manufacturing sectors, as well as the Energy and Others, experience a fall in real wages immediately after the shock. The competition from Chinese imports is so severe in these areas that the positive effects arising from cheaper Chinese goods are not sufficient to offset the negative effects associated with a fall in demand for UK/USA goods. The fall in wages can be as high as 2.3% in the USA and 1.5% in the UK one year after the shock in the Energy and Others sector. On the other hand, real wages increase in High-Tech Manufacturing by 1% in the USA and in the UK one year after the shock. And the shares of workers in sectors negatively affected by China in the two countries are not very large: Approximately 10% in the USA and 8% in the UK (considering the initial steady state equilibrium).

Figure 6 displays unemployment rates by sector in the UK and in the USA. Initially, there is a rise in unemployment in Energy and Others, Low-Tech and Mid-Tech Manu-

Figure 6: Unemployment Rate per Sector in the UK and in the USA



NOTES: Transition paths of UK and USA unemployment rates per sector following an unanticipated increase in Chinese productivity ($A_{k,CHN}$) of 9.8% and a fall in Chinese import and export costs ($d_{k,oCHN}$ and $d_{k,CHNi}$) of 31.6% and 33%, respectively, in all sectors apart from Services. Legend in panel (a) is valid for both panels.

facturing, followed by another jump downwards. This pattern occurs because after the initial shock, a mass of jobs is destroyed in these sectors. Then, in the next period, unemployed workers start to move toward sectors in which conditions are relatively better. The opposite pattern takes place in Services and Mid-Tech Manufacturing.

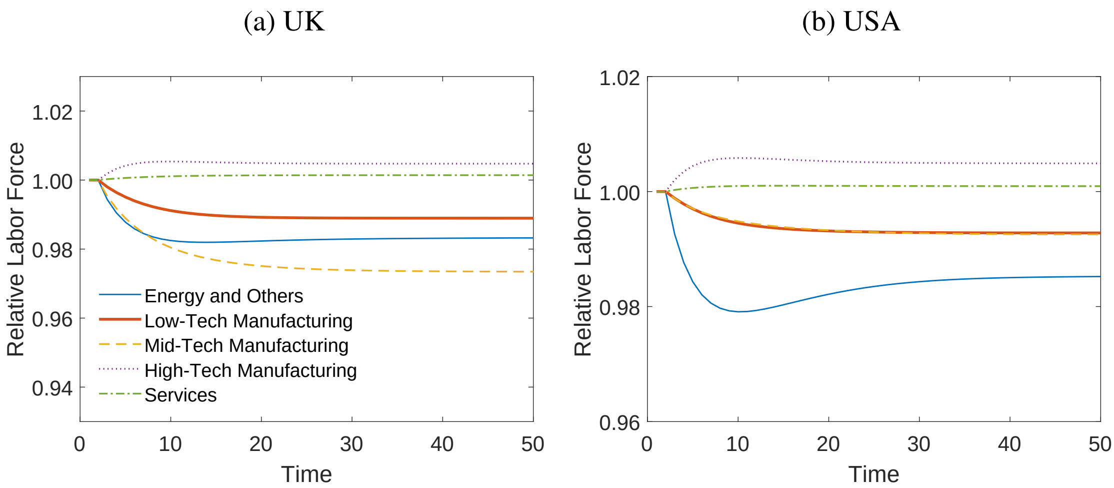
Interestingly, the shock is not strong enough to produce permanent significant changes in real wages and unemployment rates like the ones observed in China, where the real average wage increases by approximately 10% in the new steady state. Figure 7 shows relative labor forces across sectors in the UK and in the USA. One can see that as labor supply rises in the winning sectors and fall in the import competing ones, most of the unemployment and real wage effects vanish.

4.1.1 Robustness

I also verify the robustness of my results to changes in parameters values. In my robustness exercises, I consider only the aggregate effects by country and the effects by sector in the USA only.

For example, reducing λ to 1.877 (from Table 1, column 1), raises overall welfare gains (and real consumption), as countries benefit more from differences in comparative advantages around the world following the shock (see Figure 13 in the appendix). It also shows less variation in changes in real wages and unemployment rates across sectors in

Figure 7: Relative Labor Force per Sector in the UK and in the USA



NOTES: Transition paths of USA and UK labor forces per sector relative to the initial steady state equilibrium following an unanticipated increase in Chinese productivity ($A_{k,CHN}$) of 9.8% and a fall in Chinese import and export costs ($d_{k,oCHN}$ and $d_{k,CHNi}$) of 31.6% and 33%, respectively, in all sectors apart from Services. Legend in panel (a) is valid for both panels.

the USA.

Figure 14 in the appendix shows that reducing the variance of the labor shock (using $1/\zeta_i = 5.641$ from Table 3, column 3 in Panel B) basically does not change the results. In principle, this could be due to the fact that I am re-calibrating other parameters in my model such that the economy in the baseline period matches the 2005 data. However, results remain stable even if I consider a slightly different exercise where I first change the ζ_i's (relative to my baseline economy), compute a new equilibrium and then apply the trade shock (i.e., only ζ_i changes).

I consider heterogeneous values of ζ_i and $C_{k',i}$ across countries in figure 15. To compute different values for these parameters, I use "labor market freedom" index data.[36] By starting from my USA estimates of ζ_i and $C_{k',i}$, I simply increase (or decrease) the values of the parameters for each country such that proportional differences between the USA and a given country match the ones observed in the index data. One can see that results do not change significantly. However, it is important to point out that welfare *levels* are different in this counterfactual (as well as in the one presented in Figure 14), as suggested by my preliminary analysis performed in Sub-section 2.7.

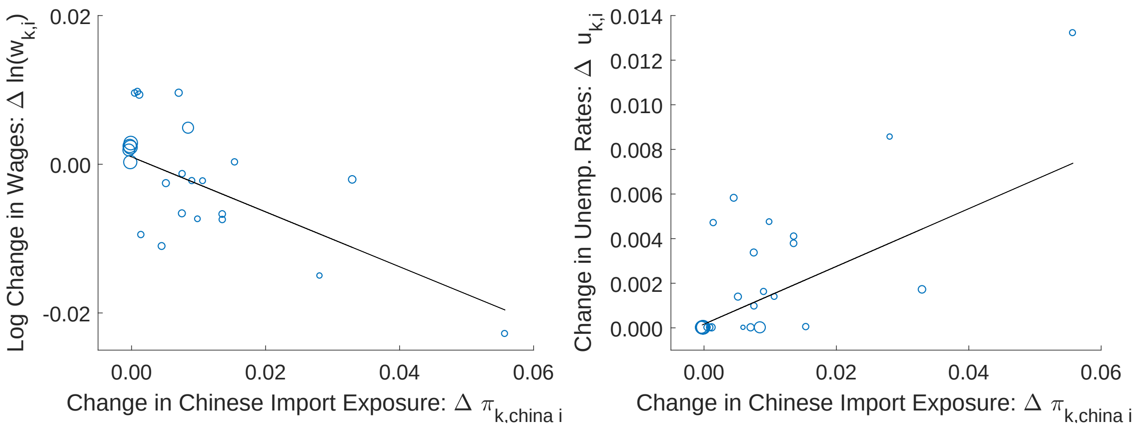
[36] Available at http://www.theglobaleconomy.com/rankings/herit_labor_freedom/.

4.2 Simulations

The previous counterfactual results show that all countries gain from more trade with China. However, workers in some sectors experience a fall in real wages and a rise in unemployment levels following the emergence of China. This occurs because in these sectors the levels of import competition are strong, and hence, workers suffer the negative effects from a fall in demand for goods produced domestically. In these cases, the negative effects generated by more import exposure to Chinese products outweighs the positive effects from a fall in consumption prices and a rise in in workers' option values.

Figure 8: Counterfactual Correlations

(a) Log Wage Changes per Sector (b) Unemployment Rate Changes per Sector



NOTES: Panels (a) and (b) plot changes in real wages and unemployment rates, respectively, on changes in Chinese import exposure in a country-sector pair (as well as a linear fit weighted by employment size in the country-sector in the initial steady state) following an unanticipated increase in Chinese productivity ($A_{k,CHN}$) of 9.8% and a fall in Chinese import and export costs ($d_{k,oCHN}$ and $d_{k,CHNi}$) of 31.6% and 33%, respectively, in all sectors apart from Services. All changes calculated one year after the initial shock. Correlation = -0.47 in panel (a); Correlation = 0.59 in panel (b).

The negative *relative* effects (across sectors) of Chinese imports on workers outside China can be seen in Figures 8a and 8b, that plot changes in real wages and unemployment rates, respectively, on changes in Chinese import exposure in a country-sector pair (as well as a linear fit weighted by employment size in the country-sector in the initial steady state). Figure 8a shows a negative correlation of -0.47 between changes in wages and changes in Chinese import competition, and Figure 8b presents a positive correlation of 0.59 between changes in unemployment rates and changes in imports from China (all changes calculated one year after the initial shock).

In this section, my aim is to provide a connection between the structural and reduced form trade-labor literatures. I use my model to simulate workers' wages and employment history over seven years following the China liberalization episode.[37] Then, by building on the methodology from Autor, Dorn, Hanson, and Song (2014) and Pessoa (2018), I run reduced form regressions using simulated data and compare my results to the ones obtained in the two papers. Differently from the reduced form literature, however, my simulated exercise is based on a general equilibrium model that allows welfare analysis, and hence, can be used to guide the interpretation of the reduced form evidence.

I conduct my simulations as follows. First, I sample one million workers (with replacement) in each country and compute workers' industry of activity in the initial steady state (in the end of period $t0$) and its change in import exposure up to year 7 ($t7$) after the China shock. Then, I simulate workers' idiosyncratic productivity and preference shocks (x and $\nu^{t}_{k,i}(l)$, respectively) from the first to the seventh year during the adjustment period. This will allow me to compute workers' wages and employment status for the seven years following the rise of China.

I focus my analysis on UK and USA workers that were initially employed in manufacturing sectors, i.e., all sectors apart from Services and Energy and Others, as in Autor, Dorn, Hanson, and Song (2014). They argue that under a certain level of mobility frictions between sectors, import shocks to the workers' initial industry should affect his/her employment and earnings history from $t1$ onwards. Hence, my basic estimation equation is:

$$y^{lk}_{t1/t7} = \alpha_1 y^{lk}_{t0} + \alpha_2 \Delta_{t0/t7} \frac{Imports^{lk}_{chi}}{Expenditure^{lk}} + \alpha_3' Z^{lk} + \varepsilon^{lk}. \tag{29}$$

The outcomes I analyze are represented by $y^{lk}_{t1/t7}$, which will be one of two possible variables for employee l working in industry k (in $t0$) from period $t1$ to $t7$: i) Total Working Years - the number of years employed between $t1$ ans $t7$; ii) log of Real Total Earnings, which is simply equivalent to total real annual wages in my model. The change in import exposure from China between $t0$ and $t7$ in the worker's initial industry of activity is given by $\Delta_{t0/t7}\frac{Imports^{lk}_{chi}}{Expenditure^{lk}}$, which is equivalent to $\pi^{t7}_{k,i} - \pi^{t0}_{k,i}$ in my model (considering worker l industry at time $t0$). In this specification, I include workers' (log) wages in the initial period (y^{lk}_{t0}) and the values of idiosyncratic productivity shocks between $t1$ and $t7$ as controls (I assume $x = 0$ during unemployment spells).

[37] I choose 7 years because it is the same time frame considered in Pessoa (2018) (from the year China joined the WTO, 2001, up to the year before the great recession, 2007).

The previous specification is closer to Pessoa (2018), who analyzes the effect of China on UK workers. To compare my simulated results with those of the USA from Autor, Dorn, Hanson, and Song (2014), I use a specification more similar to theirs:

$$\frac{\sum_{t1}^{t7} w_t^{lk}}{w_{t0}^{lk}} = \tilde{\alpha}_2 \frac{\Delta_{t0/t7} Imports_{chi}^{lk}}{Expenditure_{t0}^{lk}} + \tilde{\alpha}_3{}' Z^{lk} + \tilde{\varepsilon}^{lk}. \tag{30}$$

Note two differences: First, I use their measure of Chinese import exposure, which is now defined as the change in Chinese imports between $t0$ and $t7$ divided by the expenditure in a country in $t0$, $\frac{\Delta_{t0/t7} Imports_{chi}^{lk}}{Expenditure_{t0}^{lk}}$; Second, the dependent variable is now a normalized measure, which is defined either as total earnings between $t0$ and $t7$ divided by annual earning in $t0$ (Normalized Total Earnings) or as total working years between $t0$ and $t7$ (equivalent to Total Working Years previously defined).

Table 4 presents the results for the USA. All columns in panels A and B include workers' wages at time $t0$ as a control. In the first column, which presents the OLS results, one can observe that the coefficients are negative and significant. Controlling for random idiosyncratic productivity shocks in column 2 changes the coefficients slightly, but results remain negative and significant. In column 3, I use $Imports_{chi}^{lk}/Expenditure^{lk}$ at time time $t0$ as an instrumental variable for the change in Chinese import penetration. The instrument decreases the absolute values of the coefficients in all panels, but differences are small. My first stages are very strong, as indicated by the Kleibergen-Paap statistics (significant at all reasonable levels) in the lower part of the panels of columns 3 and 4. When I control for worker's idiosyncratic productivity shocks in column 4, my preferred specification, the coefficients change their magnitudes slightly, but remain negative and significant.

Column 4 of Panel A shows a negative effect of imports from China on USA workers' wages. Comparing a worker initially employed in an industry at the 75^{th} percentile[38] of Chinese import exposure ($\Delta_{t0/t7} \frac{Imports_{chi}^{lk}}{Expenditure^{lk}} = 0.012$) with a worker employed in an initial industry at the 25^{th} percentile of Chinese exposure ($\Delta_{t0/t7} \frac{Imports_{chi}^{lk}}{Expenditure^{lk}} = 0.001$), column 4 shows that an employee in the 75^{th} percentile observed his Total Earnings fall by 17.37% $= 100 * (-15.79) * (0.012 - 0.001)$ more than an employee at the 25^{th} percentile.

In Panel B, one can see that Chinese import exposure decreases the number of years

[38] See Table 8 in the appendix.

Table 4: Simulations USA

	(1) OLS	(2) OLS	(3) 2SLS	(4) 2SLS
Panel A		**Total Earnings**		
$\Delta_{t0/t7}\frac{Imports_{chi}}{Expenditure}$	-14.555***	-16.038***	-14.438***	-15.788***
	(0.150)	(0.160)	(0.150)	(0.160)
$Wage_{t0}$	Yes	Yes	Yes	Yes
Panel B		**Total Working Years**		
$\Delta_{t0/t7}\frac{Imports_{chi}}{Expenditure}$	-2.182***	-1.623***	-2.162***	-1.578***
	(0.401)	(0.543)	(0.402)	(0.545)
$Wage_{t0}$	Yes	Yes	Yes	Yes
Panel C		**Normalized Income**		
$\frac{\Delta_{t0/t7}Imports_{chi}}{Expenditure_{t0}}$	-20.106***	-16.318***	-19.492***	-15.665***
	(2.030)	(0.974)	(2.033)	(0.975)
$Wage_{t0}$	No	No	No	No
Panel D		**Total Working Years**		
$\frac{\Delta_{t0/t7}Imports_{chi}}{Expenditure_{t0}}$	-2.208***	-2.119***	-2.189***	-2.095***
	(0.394)	(0.381)	(0.395)	(0.382)
$Wage_{t0}$	No	No	No	No
KP F-stat			70414175	70399843
Observations	108393	108393	108393	108393
Productivity Shocks	No	Yes	No	Yes

NOTES: Table shows regressions using simulated data for USA workers employed in manufacturing industries in $t0$ following an unanticipated increase in Chinese productivity ($A_{k,CHN}$) of 9.8% and a fall in Chinese import and export costs ($d_{k,oCHN}$ and $d_{k,CHNi}$) of 31.6% and 33%, respectively, in all sectors apart from Services in $t1$. Panels A, B, C and D represent the following dependent variables for employee i working in industry j (in $t0$) in the period that goes from $t1$ to $t7$: Panel A) Total Earnings, which is equal to the log of total earnings between $t1$ and $t7$; Panels B) and D) Total Working Years - the number of years employed between $t1$ and $t7$; Panel C) Normalized Income - total earnings between $t1$ and $t7$ divided by annual earnings at $t0$. Panel A excludes individuals with zero years of employment from $t1$ to $t7$. Columns 1-2 estimated by OLS and columns 3-4 by 2SLS. Change in import penetration ($t0$-$t7$) relative to workers' industry of employment in $t0$. Instrument for change in industry Chinese import penetration is equal to industry import penetration from China in $t0$. Panels A and B include "$Wage_{t0}$" as a control, which is equal to log of worker's earnings in $t0$. Columns 2 and 4 include "Productivity Shocks" as controls, which are equal to the values of idiosyncratic productivity shocks (x) between $t1$ and $t7$ (and equal to 0 during unemployment spells). Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

spent on employment (Total Working Years) between $t1$ and $t7$, but the effect is small. In column 4 of this same panel, a worker initially employed in an industry at the 75^{th} percentile of Chinese import exposure spent approximately $0.02 = (-1.578) * (0.012 - 0.001)$ more years without a job when compared to a worker at the median. Panels C and D of Table 4 show the results considering specification 30. Results remain basically unchanged.

Interestingly, the effects displayed in Panel C of Table 4 are not very different from the ones estimated by Autor, Dorn, Hanson, and Song (2014) for the USA considering the 1992-2007 period, despite the immense differences in methods. They compare workers more and less exposed to Chinese imports (75^{th} vs. 25^{th} percentiles of $\frac{\Delta_{t0/t7} Imports^{lk}_{chi}}{Expenditure^{lk}_{t0}}$) and find a relative Normalized Income difference of 45.8% between the two groups for a 16-year period (1992-2007). Considering annual changes, the relative effects are close to the ones I find in Panel C (2.86% vs. 2.46%).

Table 5 shows the same analysis for the UK. Column 4 of Panel A also shows a negative effect of imports from China on workers' wages. Comparing the same two groups of workers[39], column 4 shows that an employee in the 75^{th} percentile observed his Total Earnings fall by $2.11\% = 100*(-1.925)*(0.012-0.001)$ more than an employee at the 25^{th} percentile of Chinese import exposure. In Panel B, one can see that Chinese import exposure also decreases the number of years spent on employment (Total Working Years) between $t1$ and $t7$, and the relative effect is slightly higher than in the USA (0.026 $= (-2.388)*(0.012-0.001)$). Panels C and D of Table 5 show the results considering specification 30. The employment results seem stable (Panels B and D), but workers seem to suffer (relatively) more in terms of normalized earnings (Panel C).[40]

The relative effects in Panels A and B of Table 5 are similar to the ones estimated by Pessoa (2018) for the UK considering the 2001-2007 period and similar groups of workers (-0.14 years for Total Working Years and -4.11% for Total Earnings), despite the profound methodological disparities between the two papers.[41]

Regarding the interpretation of the reduced form regressions, both the UK and USA comparisons to the empirical literature provide evidence that reduced form analysis are not naive interpretations of the rise of China, i.e., they are able to capture the *relative* negative effects associated with this trade episode. It is very important to point out, however, that this does not imply that countries observe a drop in welfare. On the contrary. My model suggests that overall welfare increases in both countries due to more trade with China.

[39]See Table 9 in the appendix.

[40]Pessoa (2018) also finds larger coefficients in regressions considering normalized earning in the UK.

[41]Pessoa (2018) considers workers from the Energy and Others sector. The UK simulated results are robust to this specification.

Table 5: Simulations UK

	(1) OLS	(2) OLS	(3) 2SLS	(4) 2SLS
Panel A		**Total Earnings**		
$\Delta_{t0/t7}\frac{Imports_{chi}}{Expenditure}$	-2.093***	-2.049***	-1.972***	-1.925***
	(0.142)	(0.099)	(0.142)	(0.099)
$Wage_{t0}$	Yes	Yes	Yes	Yes
Panel B		**Total Working Years**		
$\Delta_{t0/t7}\frac{Imports_{chi}}{Expenditure}$	-2.192***	-2.274***	-2.297***	-2.388***
	(0.432)	(0.416)	(0.434)	(0.417)
$Wage_{t0}$	Yes	Yes	Yes	Yes
Panel C		**Normalized Income**		
$\frac{\Delta_{t0/t7}Imports_{chi}}{Expenditure_{t0}}$	-24.809***	-24.578***	-24.061***	-24.159***
	(2.048)	(0.972)	(2.057)	(0.976)
$Wage_{t0}$	No	No	No	No
Panel D		**Total Working Years**		
$\frac{\Delta_{t0/t7}Imports_{chi}}{Expenditure_{t0}}$	-2.158***	-2.302***	-2.261***	-2.417***
	(0.425)	(0.408)	(0.426)	(0.409)
$Wage_{t0}$	No	No	No	No
KP F-stat			33225894	33222050
Observations	101560	101560	101560	101560
Productivity Shocks	No	Yes	No	Yes

NOTES: Table shows regressions using simulated data for UK workers employed in manufacturing industries in $t0$ following an unanticipated increase in Chinese productivity ($A_{k,CHN}$) of 9.8% and a fall in Chinese import and export costs ($d_{k,oCHN}$ and $d_{k,CHNi}$) of 31.6% and 33%, respectively, in all sectors apart from Services in $t1$. Panels A, B, C and D represent the following dependent variables for employee i working in industry j (in $t0$) in the period that goes from $t1$ to $t7$: Panel A) Total Earnings, which is equal to the log of total earnings between $t1$ and $t7$; Panels B) and D) Total Working Years - the number of years employed between $t1$ and $t7$; Panel C) Normalized Income - total earnings between $t1$ and $t7$ divided by annual earnings at $t0$. Panel A excludes individuals with zero years of employment from $t1$ to $t7$. Columns 1-2 estimated by OLS and columns 3-4 by 2SLS. Change in import penetration ($t0$-$t7$) relative to workers' industry of employment in $t0$. Instrument for change in industry Chinese import penetration is equal to industry import penetration from China in $t0$. Panels A and B include "$Wage_{t0}$" as a control, which is equal to log of worker's earnings in $t0$. Columns 2 and 4 include "Productivity Shocks" as controls, which are equal to the values of idiosyncratic productivity shocks (x) between $t1$ and $t7$ (and equal to 0 during unemployment spells). Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

5 Conclusion

In this paper, I study how countries responded to the recent rise of Chinese trade. I build a tractable dynamic trade model that delivers simple expressions and incorporates several features that are important when studying the welfare impact of trade shocks, namely, imperfect labor markets, job heterogeneity and partial mobility frictions across sectors.

I structurally estimate the model using country-sector level and worker level data to quantify both the losses associated with labor market adjustments and the gains to consumers generated by cheaper Chinese goods and higher option values of moving across sectors. My counterfactuals show that a fall in trade barriers between China and the world benefits all countries not only in the new steady state but also along the transition period. In import competing sectors, however, workers bear a costly transition, experiencing lower wages and a rise in unemployment.

I also carry out an empirical analysis using simulated employee level panel data to guide the interpretation of the reduced form evidence of the impact of Chinese integration on workers in the UK and in the USA. My simulated reduced form regressions generate similar effects to the ones found in Pessoa (2018) and Autor, Dorn, Hanson, and Song (2014). However, my framework has one important advantage: It is based on a general equilibrium model that allows a broader interpretation. My results show that negative *relative* effects (across sectors) of more import competition on workers' wages and employment history do not necessarily imply overall welfare losses.

The results raise important policy questions. The first point is that even facing a fierce competitor such as China generally brings benefits to developed economies, implying that any policy that aims to restrict trade in the name of more protection for workers should be reconsidered. The trade shock, however, generate winners and losers in the labor market. Hence, it *may* be welfare improving finding a way to compensate the losing individuals, and let the adjustment take place without any type of intervention that hinders trade.

The reader should bear in mind that the gains stemming from trade calculated in my counterfactuals are likely to be lower bounds, because many other welfare improving channels associated with trade such as access to cheaper inputs, immigration, increases in R&D intensity, and vertical production chains, to cite just a few, are not considered in my analysis.[42]

Finally, my tractable theoretical framework allows for studying other questions that were beyond the scope of this paper. For example, it is possible to analyze local implications of foreign labor market policies (minimum wage implementation, change in unemployment benefits and creation/destruction of unions that change workers' bargain-

[42]For example, Bloom, Romer, Terry, and Reenen (2014) use a dynamic "trapped factors" model (with perfect labor markets) to analyze the impact of China's integration on the growth rate of OECD countries, finding that it increases the profit from innovation, and hence, the long-run growth rate.

ing power). My model is also appropriate to study the transition period of other types of trade shocks. Brexit is a good example.

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Appendix A - Theory

A.1 Proof Sketch of the Result in Sub-section 2.3

I provide a sketch of proof for the fact that $p^t_{k,i}z_{k,i}$ must be equal across markets that produce in equilibrium (see Sub-section 2.3). First I will show that this holds in Steady State.

Consider two varieties j and j' (all the variables associated with variety j will be identified with a (j)). Note that workers are completely mobile across varieties. Using Equation 4, the surplus sharing rule 6 and condition 7 we can write:

$$\begin{aligned}&\frac{\theta_{k,i}(j)q(\theta_{k,i}(j))}{1+r}[\int\limits_{R_{k,i}(j)}^{1}(W_{k,i}(s,j)-U_{k,i}-\Omega_{k,i})dG(s)]\\&=\frac{\theta_{k,i}(j')q(\theta_{k,i}(j'))}{1+r}[\int\limits_{R_{k,i}(j')}^{1}(W_{k,i}(s,j')-U_{k,i}-\Omega_{k,i})dG(s)],\end{aligned}\tag{31}$$

where $\Omega_{k,i}$ and $U_{k,i}$ will be equal in all markets. From the job creation condition in steady state (see 36), I can write:

$$q(\theta_{k,i}(j))\int\limits_{R_{k,i}(j)}^{1}(s-R_{k,i}(j))dG(s)=q(\theta_{k,i}(j'))\int\limits_{R_{k,i}(j')}^{1}(s-R_{k,i}(j'))dG(s),\tag{32}$$

Note that $q(\theta_{k,i})$ and $\int\limits_{R_{k,i}(j)}^{1}(s-R_{k,i}(j))dG(s)$ are decreasing in θ and $R_{k,i}$, respectively. For 32 to hold, I assume without loss of generality that $\theta_{k,i}(j)>\theta_{k,i}(j')$ and $R_{k,i}(j)<R_{k,i}(j')$, such that $J(R_{k,i}(j))=J(R_{k,i}(j'))=0$.

Under this assumption, condition 31 holds only if $\int\limits_{R_{k,i}(j)}^{1}W_{k,i}(s,j)<\int\limits_{R_{k,i}(j')}^{1}W_{k,i}(s,j')$.[43] And from the surplus sharing rule $p_{k,i}(j)z_{k,i}(j)<p_{k,i}(j')z_{k,i}(j')$ holds. However, if this is the case $J(R_{k,i}(j))<J(R_{k,i}(j'))$ because surplus, and hence, revenues and wages will be higher in market j'. This a contradiction with $J(R_{k,i}(j))=J(R_{k,i}(j'))=0$. So, we must have $p_{k,i}(j)z_{k,i}(j)=p_{k,i}(j')z_{k,i}(j')$, as well as $\theta_{k,i}(j)=\theta_{k,i}(j')$ and $R_{k,i}(j)=R_{k,i}(j')$.

To see that this must also hold outside the steady state, by rewriting 31 considering the time period immediately before the steady state T, if follows immediately that $\theta_{k,i}^{T-1}(j)=\theta_{k,i}^{T-1}(j')$.

By using the fact that $V_{k,i}^{T-1}=0$ in 1, it follows that $p_{k,i}^{T-1}(j)z_{k,i}(j)=p_{k,i}^{T-1}(j')z_{k,i}(j')$. And from the job destruction Equation 34, $R_{k,i}^{T-1}(j)=R_{k,i}^{T-1}(j')$.

Using the same steps, we can also show that this is valid for any previous period $(T-2,T-3,...)$. This completes the proof sketch.

[43] Note that $\int\limits_{R_{k,i}}^{1}(W_{k,i}(s)-U_{k,i}-\Omega_{k,i})dG(s)>0$, otherwise workers would not look for jobs.

A.2 Job Creation and Job Destruction

Free entry in the activity of posting vacancies will also result in one key equilibrium relationship:

$$\frac{p^t_{k,i} z_{k,i} \kappa (1+r)}{q(\theta^t_{k,i})} = p^{t+1}_{k,i} z_{k,i} (1-\beta_{k,i}) \int_{R^{t+1}_{k,i}}^{1} (s - R^{t+1}_{k,i}) dG(s). \tag{33}$$

This is the job creation condition, which equates the expected gain from a job to its expected hiring cost. To obtain this expression, I first use the fact that $V^t_{k,i} = 0$ due to free entry. Second, I evaluate 1 at s, and subtract the result from the same equation evaluated at at $R^t_{k,i}$ (remember that $J^t_{k,i}(R^t_{k,i}) = 0$), to get $J^t_{k,i}(s) = p^t_{k,i} z_{k,i} (1-\beta_{k,i})(s - R^t_{k,i})$. By integrating this expression over the equilibrium productivity distribution and combining the result with $V^t_{k,i} = 0$, I get Equation 33.

Another key equation comes from the fact that $J^t_{k,i}(R^t_{k,i}) = 0$. Evaluating 1 at $R^t_{k,i}$, I get the job destruction condition:

$$\begin{aligned} p^t_{k,i} z_{k,i} R^t_{k,i} = {} & b_{k,i} + (p(\theta^t_{k,i}, R^{t+1}_{k,i}) - G(R^{t+1}_{k,i}))\Omega^t_{k,i} \\ & + \frac{\beta_{k,i}}{(1-\beta_{k,i})} p^t_{k,i} z_{k,i} \kappa \theta^t_{k,i} - \frac{p^{t+1}_{k,i} z_{k,i}}{1+r} \int_{R^{t+1}_{k,i}}^{1} (s - R^{t+1}_{k,i}) dG(s), \end{aligned} \tag{34}$$

where $p(\theta^t_{k,i}, R^{t+1}_{k,i}) \equiv 1 - \theta^t_{k,i} q(\theta^t_{k,i})(1 - G(R^{t+1}_{k,i}))$. Only jobs with idiosyncratic productivity $x > R^t_{k,i}$ will exist at time t. To derive the job destruction condition I use once more firms' value functions and the fact $J^t_{k,i}(s) = p^t_{k,i} z_{k,i} (1-\beta_{k,i})(s - R^t_{k,i})$ - see the derivation of the job creation condition for details on this last result.

Appendix B - Equilibrium Computation and Estimation

B.1 Steady State

I analyze the steady state of the economy, henceforth omitting the superscript "t". The steady state is computed numerically by solving a non-linear system of equations. The first key equation is the Beveridge Curve, the point where transition from and to employment are equal, i.e., the number of jobs created (10) and destroyed (11) are equal:

$$u_{k,i} = \frac{G(R_{k,i})}{\theta_{k,i}q(\theta_{k,i})(1-G(R_{k,i}))+G(R_{k,i})} \tag{35}$$

The second equation is the job creation condition evaluated at steady state

$$\theta_{k,i} = q^{-1}\left(\frac{\kappa(1+r)}{(1-\beta_{k,i})\int_{R_{k,i}}^{1}(s-R_{k,i})dG(s)}\right). \tag{36}$$

Note that the function $q()$ is decreasing, and hence, invertible. This follows from the homogeneity of degree 1 of the matching function.

Additionally, the net gross flows of individuals across sectors must be zero for all sectors k, implying that $OF^{t}_{k,i}$ (14) and $IF^{t}_{k,i}$ (15) must be equal

$$\sum_{k'} s_{kk',i}L_{k,i}u_{k,i} = \sum_{k'} s_{k'k,i}L_{k',i}u_{k',i}. \tag{37}$$

I then manipulate the value functions 1, 2, 4 and 5 to get:

$$\begin{aligned} \frac{rU_{k,i}}{1+r} &= b_{k,i}+\eta_{k,i}+[1-\theta_{k,i}q(\theta_{k,i})(1-G(R_{k,i}))]\Omega_{k,i} \\ &+\frac{\theta_{k,i}q(\theta_{k,i})}{(1+r)}[\beta_{k,i}\tilde{w}_{k,i}\int_{R_{k,i}}^{1}(s-R_{k,i})dG(s)], \end{aligned} \tag{38}$$

where I used the fact that $(W_{k,i}(s)-U_{k,i}) = \beta_{k,i}J_{k,i}(s)/(1-\beta_{k,i})$ from the surplus sharing rule.

Finally, I evaluate the job destruction (34) and market clearing (21) conditions at steady state (noting that the last equation is the only one evaluated in nominal terms). After I substitute for $u_{k,i}$ (from 35) and for $\theta_{k,i}$ (from 36), the two equations at steady state together with 37 and 38 form a system of equations for the unknowns $\{L_{k,i}$, $R_{k,i}$, $\tilde{w}_{k,i}$, $U_{k,i}\ \ \forall i,k\}$. There are a total of NxK equations of the type of Equation 21), but only Nx$K-1$ independent ones. I have to assume that one good is the numeraire and normalize one of the (nominal) $\tilde{w}_{k,i}$'s or one of the price indexes.

B.2 Transition

I want to find a set of value functions that is consistent with a path that converges to the new steady state. I will use numerical simulations to find this transition path. I am neither claiming that this is the first best path nor the unique one. I am simply finding one set of value functions compatible with a rational expectations path.

I use a type of multiple shooting algorithm that builds on Artuç, Chaudhuri, and McLaren (2010), Artuç, Chaudhuri, and McLaren (2008) and Lipton, Poterba, Sachs, and Summers (1982). In my algorithm I have to assume a certain number of years for the transition period to occur.[44] I consider 90 years, but the higher the number of years assumed the closer the variables of the system are to their new steady state values in the final period of the algorithm. In my numerical simulations more than 99% of the adjustment has taken place in year 89 (and most variables have already converged in year 50).

First I derive a simpler expression for $U^t_{k,i}$. After performing manipulations similar to the ones I used to derive Equation 38, I can write

$$\begin{aligned} U^t_{k,i} &= b_{k,i} + \eta_k + [1 - \theta^t_{k,i} q(\theta^t_{k,i})(1 - G(R^{t+1}_{k,i}))]\Omega^t_{k,i} \\ &+ \frac{\theta^t_{k,i} q(\theta^t_{k,i})}{(1+r)} [\beta_{k,i} \tilde{w}^{t+1}_{k,i} \int_{R^{t+1}_{k,i}}^{1} (s - R^{t+1}_{k,i}) dG(s) + U^{t+1}_{k,i}]. \end{aligned} \tag{39}$$

I can also rewrite expressions 33 and 34 as

$$\theta^t_{k,i} = q^{-1}\left(\frac{\tilde{w}^t_{k,i} \kappa (1+r)}{\tilde{w}^{t+1}_{k,i}(1-\beta_{k,i}) \int_{R^{t+1}_{k,i}}^{1} (s - R^{t+1}_{k,i}) dG(s)}\right), \tag{40}$$

[44] Such types of non-linear systems of equations can only be guaranteed to converge asymptotically - see Lipton, Poterba, Sachs, and Summers (1982).

$$
\begin{aligned}
R^t_{k,i} = & \frac{1}{\tilde{w}^t_{k,i}}[b_{k,i} + (p(\theta^t_{k,i}, R^{t+1}_{k,i}) - G(R^{t+1}_{k,i}))\Omega^t_{k,i}] \\
& + \frac{\beta_{k,i}}{(1-\beta_{k,i})}\kappa\theta^t_{k,i} - \frac{\tilde{w}^{t+1}_{k,i}}{\tilde{w}^t_{k,i}(1+r)} \int_{R^{t+1}_{k,i}}^{1} (s - R^{t+1}_{k,i}) dG(s),
\end{aligned}
\tag{41}
$$

The algorithm works in two separate "layers": i) given $R^t_{k,i}$'s and $\theta^t_{k,i}$'s, I calculate equilibrium $\tilde{w}^t_{k,i}$'s, $U^t_{k,i}$'s, $L^t_{k,i}$'s and $u^t_{k,i}$'s; ii) I then proceed to update the values of $R^t_{k,i}$'s and $\theta^t_{k,i}$'s and I stop when convergence is achieved.[45] More precisely, it works as follows:

1. I calculate a steady state equilibrium at $t = 0$ as described in Appendix B.1.
2. I assume a change in an subset of the parameters at $t = 1$ and conjecture that the system will converge to a new steady state in a certain amount of time, say T_{ss}.
3. I guess values for $\{R^t_{k,i}, \theta^t_{k,i}\ \forall i,k\}_{t=1}^{T_{ss}-1}$.
4. I also guess values for $\{U^t_{k,i}\ \forall i,k,x\}_{t=1}^{T_{ss}-1}$ (in real terms) and $\{\tilde{w}^t_{k,i}\ \forall i,k\}_{t=1}^{T_{ss}-1}$ (in nominal terms).
5. For given values of $R^t_{k,i}$'s and $\theta^t_{k,i}$'s:
   (i) Production takes place at $t = 1$ and I use the market clearing condition 21 to compute new values for the $\tilde{w}^{t=1}_{k,i}$'s, noticing that that the labor force is fixed in each sector and that some jobs will be destroyed immediately if $R^{t=0}_{k,i} < R^{t=1}_{k,i}$.
   (ii) Search and matching take place and I use 10 and 11 to calculate the number of jobs created and destroyed, respectively.
   (iii) By the end of the period workers will know their idiosyncratic moving shocks, and I use 14 and 15 to calculate the inflow and outflow of unemployed workers in each sector.
   (iv) I proceed like this from period $t = 1$ to $t = T_{ss} - 1$, obtaining a new sequence of $\{\tilde{w}^t_{k,i}\ \forall i,k\}_{t=1}^{T_{ss}-1}$, as well as $\{L^t_{k,i}, u^t_{k,i}\ \forall i,k\}_{t=1}^{T_{ss}-1}$.
   (v) With the new $\tilde{w}^t_{k,i}$'s, I use Equation 39 to update the values of $U^t_{k,i}$'s from $t = T_{ss} - 1$ to $t = 1$ (assuming that the economy is in the new steady state at $t = T_{ss}$).

[45] The algorithm is conducted in two layers to facilitate convergence.

(vi) I then compare the updated $\tilde{w}^t_{k,i}$'s and $U^t_{k,i}$'s to their previous values. If they are close enough according to my tolerance I move to step 6. Otherwise, I restart the algorithm at step 5i using my updated values.

6. I use Equation 40 to update the $\theta^t_{k,i}$'s from $t = T_{ss} - 1$ to $t = 1$ in the following way: if $\theta^t_{k,i}$ is greater than the right-hand side of 40, I pick a slightly lower value for $\theta^t_{k,i}$, otherwise I pick a slightly higher value. I update the $R^t_{k,i}$'s analogously using Equation 41.[46]

7. I then compare the updated $\theta^t_{k,i}$'s and $R^t_{k,i}$'s to their previous values. If they are close enough according to my tolerance I stop. Otherwise, I restart the algorithm at step 5 using my updated values.

8. Finally, I check whether all endogenous variables and value functions are close (given a tolerance) to their steady state values at $t = T_{ss} - 1$. If they are not, I increase the value of T_{ss} and restart the procedure at step 1.

In the algorithm there is one implicit simplifying assumption that is not necessary to find the steady state equilibrium. I assume that if a variety ceases to be produced in a sector at some point in time, all matches producing that variety with an idiosyncratic productivity level above the equilibrium threshold $R^t_{k,i}$ can freely reallocate to a producing variety (pushing low productivity matches out of business and reinforcing the effect on $R^t_{k,i}$). Without this assumption, the problem would be significantly more complicated as the identity of the variety would also be a choice variable for the agents in the economy.

B.3 Estimating Equation

Here I derive estimating Equation 28. Note that I can integrate Equation 5 over the productivity distribution at time t and divide both sides of the equation by $(1 - G(R^t_{k,i}))$ to obtain:

$$\begin{aligned} \bar{W}^t_{k,i} = \bar{w}^t_{k,i} + \eta_{k,i} + G(R^{t+1}_{k,i})\Omega^t_{k,i} \\ + \frac{1}{1+r}[(1 - G(R^{t+1}_{k,i}))\bar{W}^{t+1}_{k,i} + G(R^{t+1}_{k,i})U^{t+1}_{k,i}], \end{aligned} \tag{42}$$

[46]This is a "smoother" way to update the values of $\theta^t_{k,i}$ and $\theta^t_{k,i}$. It is harder to achieve convergence if I update their values using the equalities in expressions 40 and 41 directly.

where $\bar{W}^t_{k,i} = \frac{1}{1-G(R^t_{k,i})} \int\limits_{R^t_{k,i}}^{1} W^t_{k,i}(s)dG(s)$, and $\bar{w}^t_{k,i} = \frac{1}{1-G(R^t_{k,i})} \int\limits_{R^t_{k,i}}^{1} w^t_{k,i}(s)dG(s)$.

Now, substituting $R^t_{k,i}$ for x in 5, subtracting $W^t_{k,i}(R^t_{k,i})$ from $\bar{W}^t_{k,i}$ in 42 and using the fact that separations are efficient ($U^t_{k,i} = W^t_{k,i}(R^t_{k,i})$) I can write:

$$\bar{W}^t_{k,i} = U^t_{k,i} + \bar{w}^t_{k,i} - w^t_{k,i}(R^t_{k,i}) \tag{43}$$

Rewriting 4 as a function of $\bar{W}^{t+1}_{k,i}$ and substituting for it from 43, I have that

$$\begin{aligned} U^t_{k,i} &= b_{k,i} + \eta_{k,i} + [1 - \theta^t_{k,i} q(\theta^t_{k,i})(1 - G(R^{t+1}_{k,i}))]\Omega^t_{k,i} \\ &+ \frac{1}{1+r}[\theta^t_{k,i} q(\theta^t_{k,i})(1 - G(R^{t+1}_{k,i}))(\bar{w}^{t+1}_{k,i} - w^{t+1}_{k,i}(R^{t+1}_{k,i})) + U^{t+1}_{k,i}]. \end{aligned}$$

Substituting for $\Omega^t_{k,i}$ (from 27) and rearranging

$$\begin{aligned} &U^t_{k,i}/(1+r)\zeta_i - U^t_{o,i}/(1+r)\zeta_i + U^t_{o,i}/(1+r)\zeta_i \\ &= (b_{k,i} + \eta_{k,i})/(1+r)\zeta_i \\ &+ [1 - \theta^t_{k,i} q(\theta^t_{k,i})(1 - G(R^{t+1}_{k,i}))](-D^t_{k,i} - O^t_{k,i} + log(L^t_{k,i} u^t_{k,i}))/(1+r) \\ &+ \frac{1}{1+r}[\theta^t_{k,i} q(\theta^t_{k,i})(1 - G(R^{t+1}_{k,i}))(\bar{w}^{t+1}_{k,i} - w^{t+1}_{k,i}(R^{t+1}_{k,i})) + U^{t+1}_{k,i} - U^{t+1}_{o,i} + U^{t+1}_{o,i}]/(1+r)\zeta_i, \end{aligned}$$

which is Equation 28 (without the error term).

B.4 Summary Statistics

Table 6: Summary Statistics

	Job Finding Rate	Average Wage	5^{th} Wage Percentile	1^{st} Wage Percentile
Agriculture and Others	0.763	0.857	0.283	0.146
Low-tech Manuf.	0.861	1.135	0.404	0.300
Mid-tech Manuf.	0.838	1.137	0.419	0.308
High-tech Manuf.	0.809	0.928	0.369	0.264
Services	0.856	0.980	0.317	0.171

NOTES: Summary statistics for the sample of workers between 25 and 65 years of age for the period 1983-2002. Data is the CPS "March Supplement", obtained from IPUMS, aggregated up to the industry level. Wage is defined as workers annual earnings (total pre-tax wage and salary income) in year t (using the appropriate CPS weights). All variables are adjusted to real 1999 USD using the CPI-U provided by IPUMS. The average real wage in the sample is normalized to 1. The job finding rate is equivalent to job finding rate, $\theta^t_{k,i}q(\theta^t_{k,i})(1-G(R^{t+1}_{k,i}))$ in my model.

Table 7: Movement across Sectors

	Agriculture and Others	Low-tech Manuf.	Mid-tech Manuf.	High-tech Manuf.	Services
Agriculture and Others	0.58	0.03	0.01	0.03	0.35
Low-tech Manuf.	0.01	0.49	0.04	0.05	0.41
Mid-tech Manuf.	0.02	0.11	0.43	0.05	0.40
High-tech Manuf.	0.02	0.10	0.03	0.48	0.38
Services	0.01	0.04	0.01	0.02	0.90

NOTES: Table presents the average (over time) share of workers that move across sectors (row origin and column destination) for the sample of individuals between 25 and 65 years of age for the period 1983-2002. Data is the CPS "March Supplement", obtained from IPUMS, aggregated up to the industry level.

Table 8: Simulations Summary Stats: USA

	Mean	Min	p_{25}	p_{50}	p_{75}	Max
$\frac{\Delta_{t0/t7} Imports_{chi}}{Expenditure_{t0}}$	0.007	0.001	0.001	0.010	0.012	0.012
$\Delta_{t0/t7}\frac{Imports_{chi}}{Expenditure}$	0.007	0.001	0.001	0.010	0.012	0.012

NOTES: Summary statistics for the full sample of individuals from years $t1$ to $t7$ using simulated data for USA workers employed in manufacturing industries in $t0$ following an unanticipated increase in Chinese productivity ($A_{k,CHN}$) of 9.8% and a fall in Chinese import and export costs ($d_{k,oCHN}$ and $d_{k,CHNi}$) of 31.6% and 33%, respectively, in all sectors apart from Services in $t1$.

Table 9: Simulations Summary Stats: UK

	Mean	Min	p_{25}	p_{50}	p_{75}	Max
$\frac{\Delta_{t0/t7} Imports_{chi}}{Expenditure_{t0}}$	0.007	0.001	0.001	0.012	0.012	0.012
$\Delta_{t0/t7}\frac{Imports_{chi}}{Expenditure}$	0.007	0.001	0.001	0.012	0.012	0.012

NOTES: Summary statistics for the full sample of individuals from years $t1$ to $t7$ using simulated data for UK workers employed in manufacturing industries in $t0$ following an unanticipated increase in Chinese productivity ($A_{k,CHN}$) of 9.8% and a fall in Chinese import and export costs ($d_{k,oCHN}$ and $d_{k,CHNi}$) of 31.6% and 33%, respectively, in all sectors apart from Services in $t1$.

B.5 Other Parameters

Table 10: Productivity ($A_{k,i}^t$)

	Agriculture and Others	Low-tech Manuf.	Mid-tech Manuf.	High-tech Manuf.	Services
Panel A: 2005					
UK	1.00	1.23	1.59	1.33	1.22
EU	1.00	1.33	1.66	1.38	1.00
CHN	1.00	1.16	1.69	1.22	0.92
USA	1.00	1.00	1.00	1.00	1.00
RoW Developed	1.00	1.60	1.83	2.13	1.29
RoW Developing	1.00	0.84	1.14	0.75	0.62
Panel B: 2000					
UK	1.00	1.11	1.41	1.23	1.02
EU	1.00	1.31	1.59	1.31	1.00
CHN	1.00	1.09	1.59	0.97	0.82
USA	1.00	1.00	1.00	1.00	1.00
RoW Developed	1.00	1.62	1.89	2.03	1.37
RoW Developing	1.00	0.76	1.10	0.70	0.59

NOTES: "Revealed productivity" measure, $A_{k,i}^t$, for different countries and sectors, obtained as $exp[(\chi_{k,o}^{t_0} + t * \chi_{k,o})/\lambda]$, where $(\chi_{k,o}^{t_0} + t * \chi_{k,o})$ are estimates from Equation 24 and λ is the estimate of trade elasticity obtained from Equation 23 and shown in Table 1, column 4. Bilateral trade data from 2005 and 2000 obtained from WIOD and GGDC datasets.
EU: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Greece, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Portugal, Poland, Romania, Slovak Republic, Slovenia, Spain and Sweden.
RoW Developed: Australia, Canada, Japan, Korea (south) and Taiwan.
RoW Developing: Brazil, India, Indonesia, Mexico, Russia and Turkey.

Table 11: Labor Share ($\beta_{k,i}$), Matching Efficiency ($m_{k,i}$), and Unemployment Benefit ($b_{k,i}$)

	Agriculture and Others	Low-tech Manuf.	Mid-tech Manuf.	High-tech Manuf.	Services
Panel A: $\beta_{k,i}$					
UK	0.685	0.666	0.688	0.692	0.736
EU	0.769	0.791	0.808	0.823	0.850
CHN	0.684	0.702	0.712	0.720	0.713
USA	0.657	0.644	0.655	0.665	0.696
RoW Developed	0.737	0.764	0.764	0.787	0.805
RoW Developing	0.662	0.672	0.681	0.688	0.695
Panel B: $m_{k,i}$					
UK	0.574	0.574	0.574	0.574	0.574
EU	0.572	0.572	0.572	0.572	0.572
CHN	0.575	0.575	0.575	0.575	0.575
USA	0.580	0.580	0.580	0.580	0.580
RoW Developed	0.572	0.572	0.572	0.572	0.572
RoW Developing	0.579	0.579	0.579	0.579	0.579
Panel C: $b_{k,i}$					
UK	0.529	0.530	0.529	0.529	0.528
EU	0.503	0.500	0.500	0.498	0.499
CHN	0.527	0.529	0.529	0.529	0.529
USA	0.541	0.540	0.540	0.539	0.543
RoW Developed	0.512	0.510	0.510	0.509	0.509
RoW Developing	0.530	0.535	0.534	0.534	0.534

NOTES: Calibrated labor shares, $\beta_{k,i}$, matching efficiencies, $m_{k,i}$, and unemployment benefits, $b_{k,i}$, for different countries and sectors. Data obtained from the WIOD, WIOD - Socio Economic Accounts databases, together with unemployment data by country from the Bureau of Labor Statistics (for the USA) and from the International Labour Organization (for the remaining countries). I match trade shares ($\pi_{k,oi}$), expenditure shares ($\mu_{k,o}$), unemployment rates ($u_{k,o}$, assuming they are equal across sectors within a country), total production values ($Y^t_{k,o}$) and labor force ($L^t_{k,o}$) per country-sector pairs to their observed values in 2005.
EU: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Greece, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Portugal, Poland, Romania, Slovak Republic, Slovenia, Spain and Sweden.
RoW Developed: Australia, Canada, Japan, Korea (south) and Taiwan.
RoW Developing: Brazil, India, Indonesia, Mexico, Russia and Turkey.

Table 12: Vacancy Cost ($\kappa_{k,i}$), Preference Parameter ($\eta_{k,i}$) and Expenditure Share ($\mu_{k,i}$)

	Agriculture and Others	Low-tech Manuf.	Mid-tech Manuf.	High-tech Manuf.	Services
Panel A: $\kappa_{k,i}$					
UK	0.061	0.064	0.060	0.059	0.051
EU	0.045	0.040	0.037	0.034	0.029
CHN	0.061	0.057	0.055	0.054	0.055
USA	0.066	0.068	0.066	0.064	0.058
RoW Developed	0.051	0.046	0.046	0.041	0.038
RoW Developing	0.065	0.063	0.061	0.060	0.058
Panel B: $\eta_{k,i}$					
UK	-26.473	-31.551	-32.317	-31.341	-17.365
EU	-10.857	-25.235	-21.006	-32.949	-14.399
CHN	-1.303	-29.234	-19.603	-49.939	-9.515
USA	-22.975	-27.405	-26.739	-31.837	-12.273
RoW Developed	-12.322	-44.895	-30.519	-49.176	-16.868
RoW Developing	-1.001	-23.393	-13.739	-41.130	-10.763
Panel C: $\mu_{k,i}$					
UK	0.033	0.066	0.057	0.055	0.787
EU	0.024	0.086	0.070	0.143	0.677
CHN	0.046	0.120	0.143	0.245	0.446
USA	0.058	0.074	0.062	0.088	0.717
RoW Developed	0.033	0.112	0.054	0.153	0.649
RoW Developing	0.081	0.104	0.132	0.026	0.657

NOTES: Calibrated vacancy costs, $\kappa_{k,i}$, preference parameters, $\eta_{k,i}$, and expenditure shares, $\mu_{k,i}$, for different countries and sectors. Data obtained from the WIOD, WIOD - Socio Economic Accounts databases, together with unemployment data by country from the Bureau of Labor Statistics (for the USA) and from the International Labour Organization (for the remaining countries). I match trade shares ($\pi_{k,oi}$), expenditure shares ($\mu_{k,o}$), unemployment rates ($u_{k,o}$, assuming they are equal across sectors within a country), total production values ($Y^t_{k,o}$) and labor force ($L^t_{k,o}$) per country-sector pairs to their observed values in 2005.
EU: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Greece, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Portugal, Poland, Romania, Slovak Republic, Slovenia, Spain and Sweden.
RoW Developed: Australia, Canada, Japan, Korea (south) and Taiwan.
RoW Developing: Brazil, India, Indonesia, Mexico, Russia and Turkey.

Table 13: Parameters used in the Counterfactuals

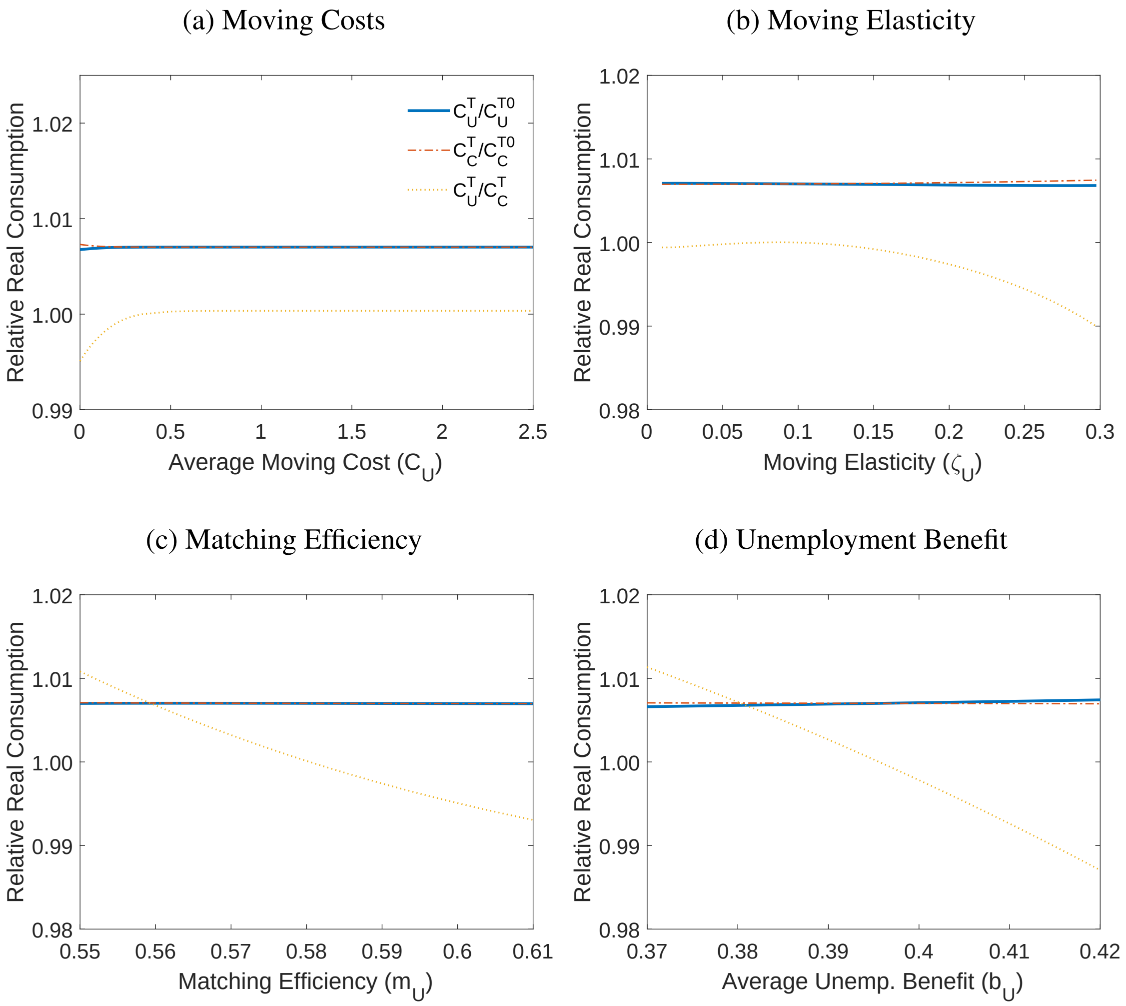
Parameter	Description	Value	How was the Parameter Obtained	Country-Specific	Sector-Specific
λ	Trade Elasticity	4.172	Estimated (see Table 1)	No	No
A	Countries' Productivity Shifter	See Table 10	Estimated	Yes	Yes
ζ_i	Variance of Workers' Preference	See Table 3 and notes below	Estimated for the USA and replicated to other countries	Yes	No
C	Labor Mobility Costs	See Table 2 and notes below	Estimated for the USA and replicated to other countries	Yes	Yes
d	Trade Costs	See Table 12 and notes below	Calibrated	Yes	Yes
μ	Expenditure Share on a Sector	See Table 11	Calibrated	Yes	Yes
η	Workers' preference common term	See Table 12	Calibrated	Yes	Yes
κ	Cost of Posting Vacancies	See Table 12	Calibrated	Yes	Yes
δ	Matching Function Elasticity	0.305	Calibrated	No	No
m	Matching Function Efficiency	See Table 11	Calibrated	Yes	No
b	Unemployment Benefits	See Table 11	Calibrated	Yes	Yes
β	Labor Share of the Surplus of the Match	See Table 11	Calibrated	Yes	Yes
r	Annual Interest Rate	0.031	Based on Artuç, Chaudhuri, and McLaren (2010)	No	No

NOTES: Parameter values used in the main counterfactual. $\zeta_i = 0.202$, and $C_{k',i}$'s are expressed as multiples of averages of income per capita in each country in the initial equilibrium. $\delta = 0.305$. Trade costs and other unobserved components that drive trade (such as unobserved quality of products) are calibrated such that trade flows match WIOD data in 2005, but the two terms cannot be separately observed.

Appendix C - Other Results

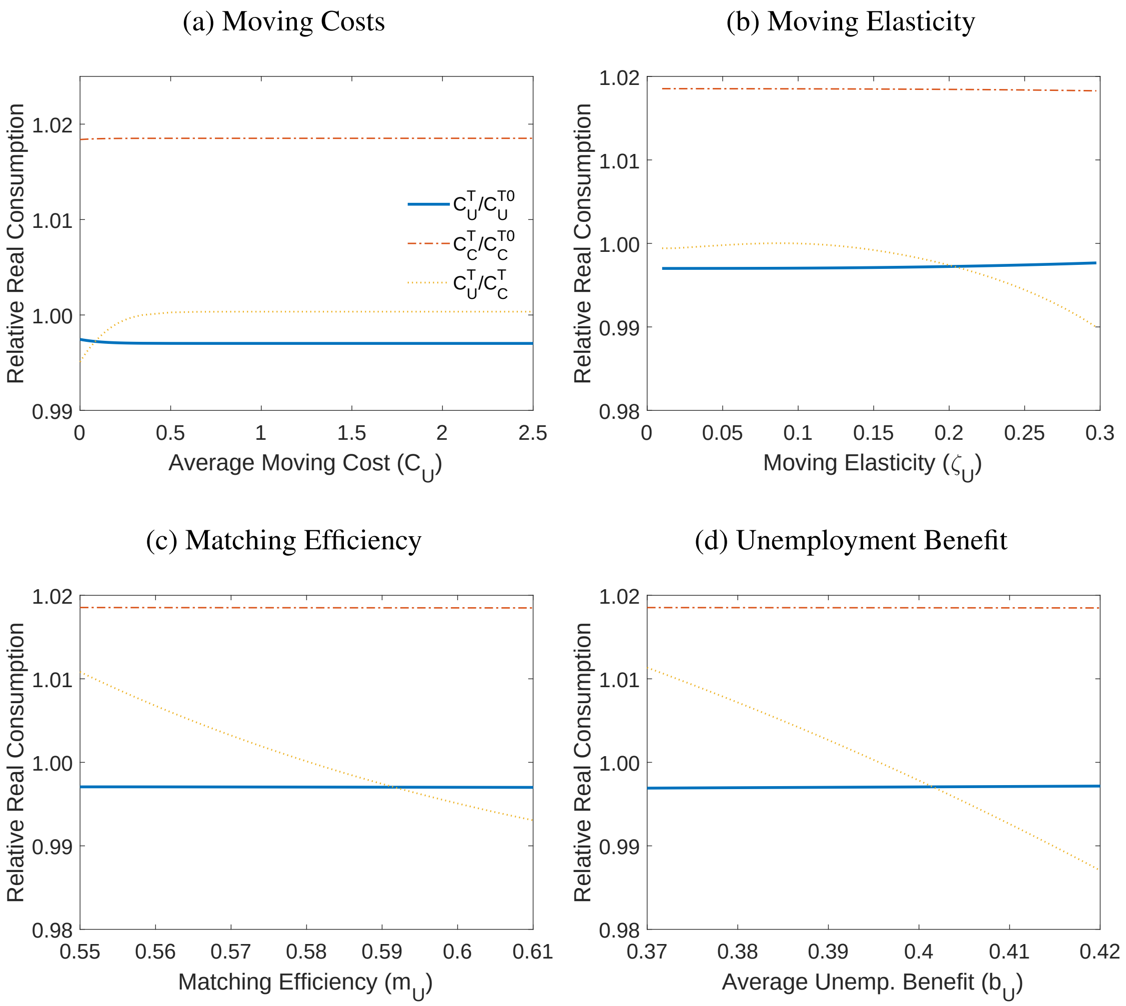
C.1 Real Consumption - Preliminary Analysis

Figure 9: Trade Cost Shock - Steady State Changes by Country



NOTES: Figures show relative real consumption values across steady states after trade costs decrease from $d_{k,CU} = d_{k,UC} = 1.05$ at time $T0$ to $d_{k,CU} = d_{k,UC} = 1$ at time T in the agricultural and manufacturing sectors in both countries for different values of parameters in country U. The solid line presents relative real consumption for country U, while the dashed line presents the equivalent measure for country C. The yellow dotted line shows relative real consumption values between the two countries at time T. The service sector has high trade costs ($d_{k,CU} = d_{k,UC} = 2$) and all countries/sectors have the same aggregate productivity parameter ($A_{k,o} = 1$). The panels consider this exercise for distinct values of four parameters of country U. Panel (a) average of $C_{kk',U}$ over sectors; Panel (b) ζ_U; Panel (c) m_U; Panel (d) average of $b_{k,U}$ over sectors.

Figure 10: Productivity Shock - Steady State Changes by Country

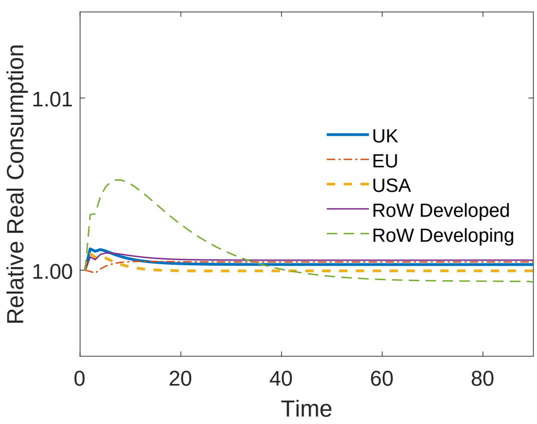


NOTES: Figures show relative real consumption values across steady states after productivity rises from $A_{k,C} = 0.95$ at time $T0$ to $A_{k,C} = 1$ at time T in the agricultural and manufacturing sectors in country C for different values of parameters in country U. The solid line presents relative real consumption for country U, while the dashed line presents the equivalent measure for country C. The yellow dotted line shows relative real consumption values between the two countries at time T. The service sector has high trade costs ($d_{k,CU} = d_{k,UC} = 2$) and the other sectors have free trade ($d_{k,CU} = d_{k,UC} = 1$). All countries/sectors have the same aggregate productivity parameter ($A_{k,o} = 1$) at time T. The panels consider this exercise for distinct values of four parameters of country U. Panel (a) average of $C_{kk',U}$ over sectors; Panel (b) ζ_U; Panel (c) m_U; Panel (d) average of $b_{k,U}$ over sectors.

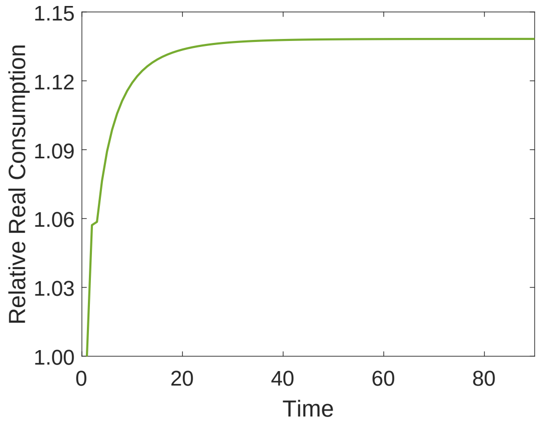
C.2 Real Consumption and Employment - Counterfactuals

Figure 11: Real Consumption

(a) World Real Consumption



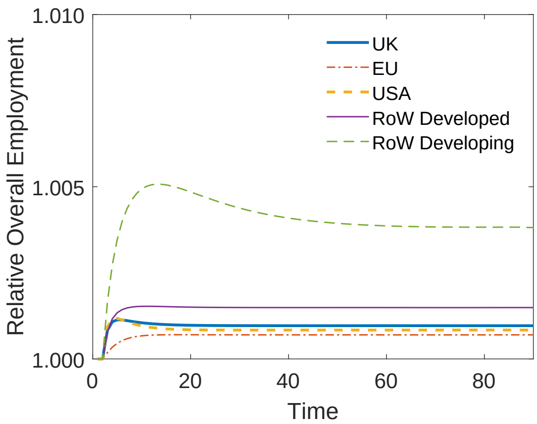
(b) China Real Consumption



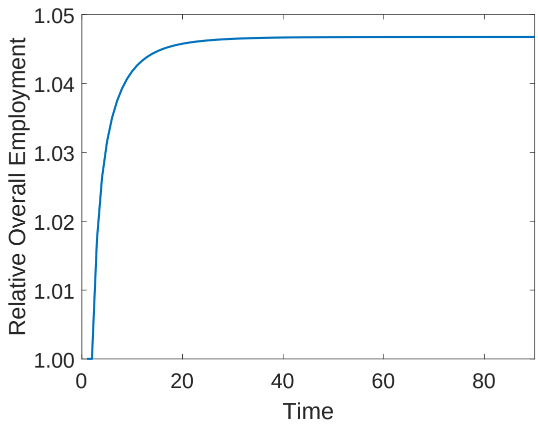
NOTES: Transition path of real consumption per country relative to the initial steady state equilibrium following an unanticipated increase in Chinese productivity ($A_{k,CHN}$) of 9.8% and a fall in Chinese import and export costs ($d_{k,oCHN}$ and $d_{k,CHNi}$) of 31.6% and 33%, respectively, in all sectors apart from Services.
EU: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Greece, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Portugal, Poland, Romania, Slovak Republic, Slovenia, Spain and Sweden.
RoW Developed: Australia, Canada, Japan, Korea (south) and Taiwan.
RoW Developing: Brazil, India, Indonesia, Mexico, Russia and Turkey.

Figure 12: Employment

(a) World Aggregate Employment



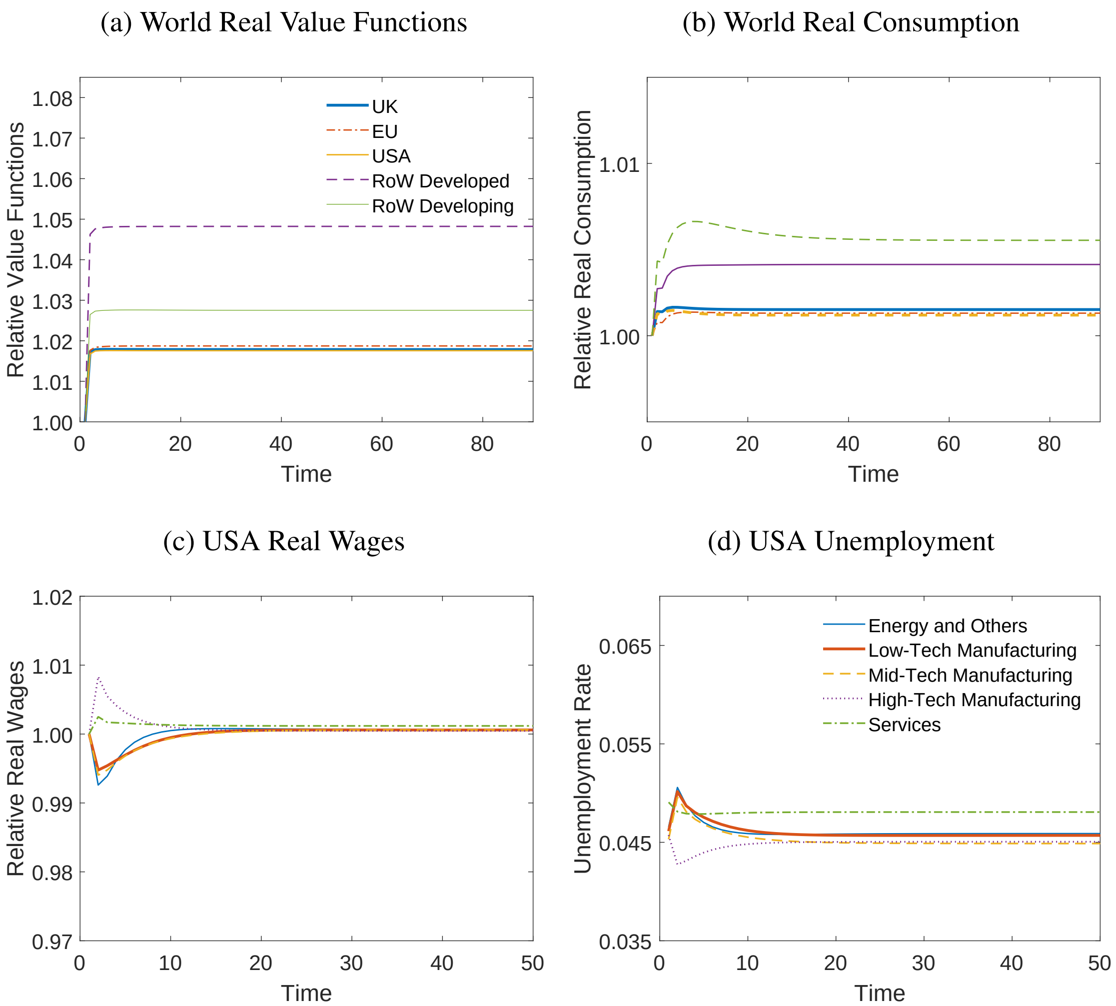
(b) China Aggregate Employment



NOTES: Transition paths of labor forces per country relative to the initial steady state equilibrium following an unanticipated increase in Chinese productivity ($A_{k,CHN}$) of 9.8% and a fall in Chinese import and export costs ($d_{k,oCHN}$ and $d_{k,CHNi}$) of 31.6% and 33%, respectively, in all sectors apart from Services.
EU: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Greece, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Portugal, Poland, Romania, Slovak Republic, Slovenia, Spain and Sweden.
RoW Developed: Australia, Canada, Japan, Korea (south) and Taiwan.
RoW Developing: Brazil, India, Indonesia, Mexico, Russia and Turkey.

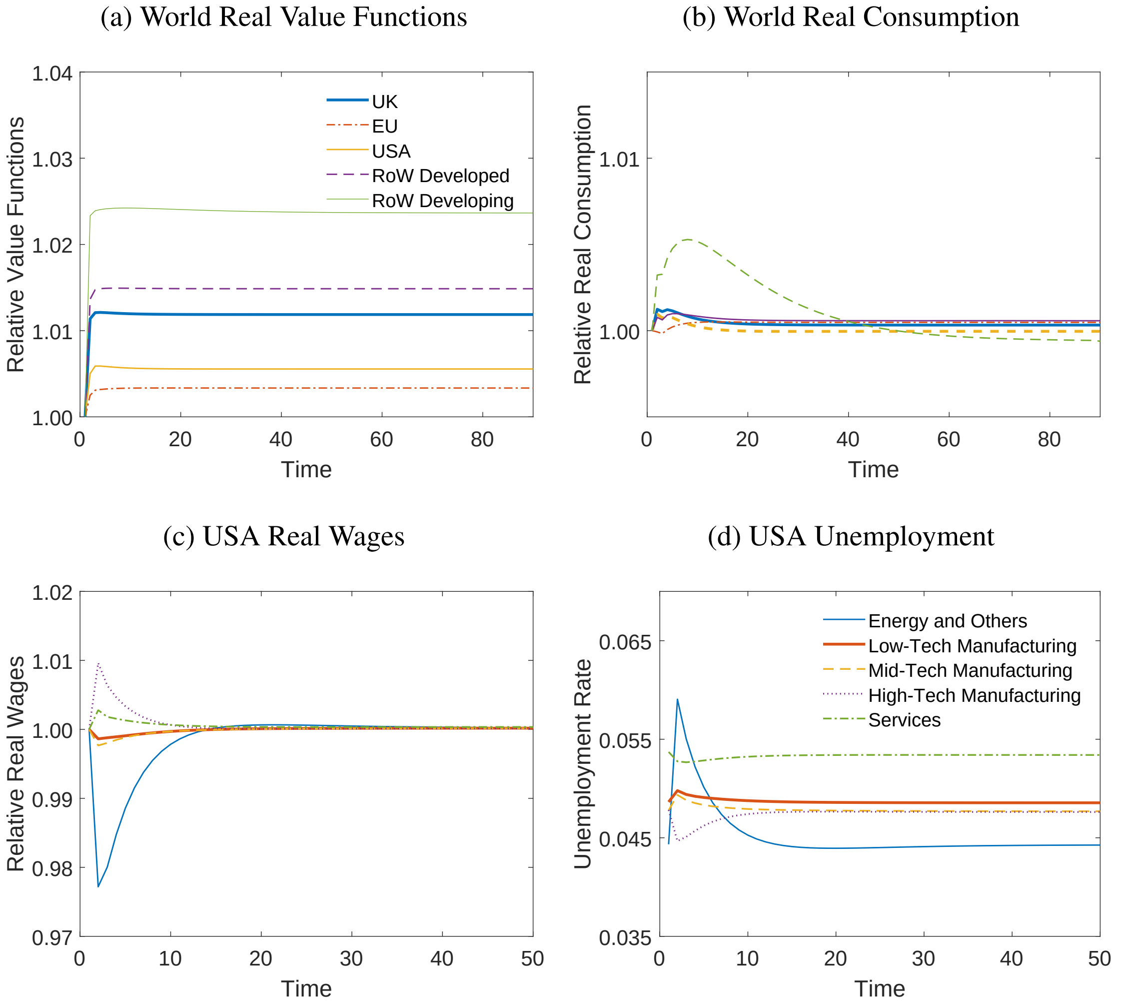
C.3 Robustness to Parameter Changes

Figure 13: Change in parameter: λ = 1.877



NOTES: Transition paths following an unanticipated increase in Chinese productivity ($A_{k,CHN}$) of 9.8% and a fall in Chinese import and export costs ($d_{k,oCHN}$ and $d_{k,CHNi}$) of 31.6% and 33%, respectively, in all sectors apart from Services. Legends of Panels A and B can be found in Panel A. Legends of Panels C and D can be found in Panel D.
EU: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Greece, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Portugal, Poland, Romania, Slovak Republic, Slovenia, Spain and Sweden.
RoW Developed: Australia, Canada, Japan, Korea (south) and Taiwan.
RoW Developing: Brazil, India, Indonesia, Mexico, Russia and Turkey.

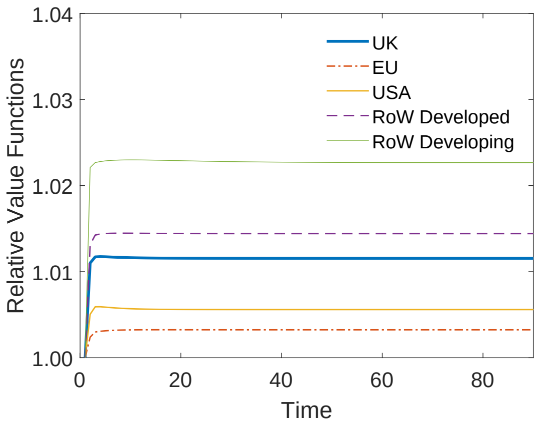
Figure 14: Change in parameter: $1/\zeta_i = 5.641$



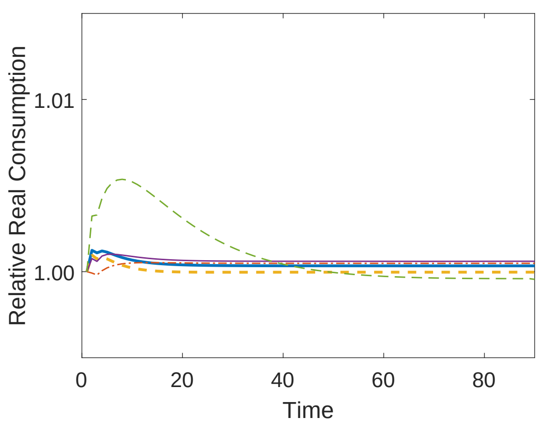
NOTES: Transition paths following an unanticipated increase in Chinese productivity ($A_{k,CHN}$) of 9.8% and a fall in Chinese import and export costs ($d_{k,oCHN}$ and $d_{k,CHNi}$) of 31.6% and 33%, respectively, in all sectors apart from Services. Legends of Panels A and B can be found in Panel A. Legends of Panels C and D can be found in Panel D.
EU: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Greece, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Portugal, Poland, Romania, Slovak Republic, Slovenia, Spain and Sweden.
RoW Developed: Australia, Canada, Japan, Korea (south) and Taiwan.
RoW Developing: Brazil, India, Indonesia, Mexico, Russia and Turkey.

Figure 15: Heterogeneous $C_{k',i}$'s and ζ_i's

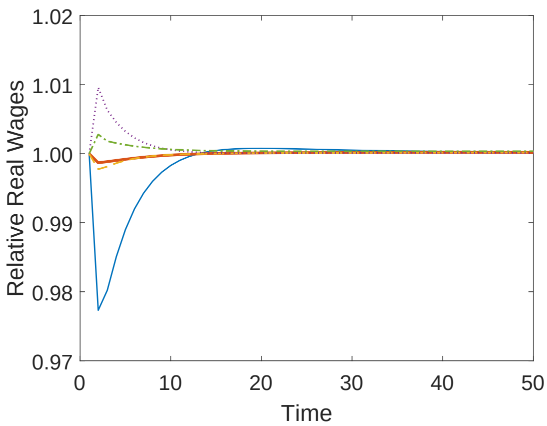
(a) World Real Value Functions



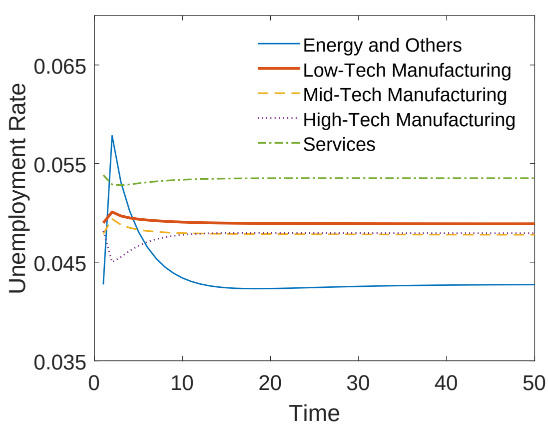
(b) World Real Consumption



(c) USA Real Wages



(d) USA Unemployment



NOTES: Transition paths following an unanticipated increase in Chinese productivity ($A_{k,CHN}$) of 9.8% and a fall in Chinese import and export costs ($d_{k,oCHN}$ and $d_{k,CHNi}$) of 31.6% and 33%, respectively, in all sectors apart from Services. Legends of Panels A and B can be found in Panel A. Legends of Panels C and D can be found in Panel D.
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