

RELATIVE PRODUCTIVITY AND SEARCH UNEMPLOYMENT IN AN OPEN ECONOMY*

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Abstract

This paper develops a tractable version of a two-sector open economy model with search frictions to disentangle the implications of workers' mobility costs and labor market institutions following higher relative productivity of tradables. Using a panel of eighteen OECD countries, our estimates show that higher productivity in tradables relative to non tradables causes a decline in non traded relative to traded wages. The fall in the relative wage reveals the presence of labor mobility costs which mitigate the appreciation in the relative price of non tradables and lower the relative unemployment rate of tradables following higher relative productivity of tradables. Whilst our evidence suggests that such responses have increased over time as the result of decreasing labor mobility costs, our estimates also reveal that the magnitude of the effects vary considerably across countries. Using a set of indicators capturing the heterogeneity of labor market frictions across economies, we find that both the relative wage and the relative unemployment rate of tradables decline significantly more and the relative price appreciates less in countries where labor market regulation is more pronounced. We show that these empirical findings can be rationalized in a two-sector open economy model with search in the labor market as long as we allow for an endogenous sectoral labor force participation decision. When we calibrate the model to country-specific data, numerical results reveal that the responses of the relative wage, the relative price, and to a lesser extent the relative unemployment rate display a wide dispersion across countries. Importantly, all variables display a significant negative relationship with labor market regulation.

Keywords: Relative productivity of tradables; Search theory; Labor market institutions; Labor mobility; Sectoral price and wage differences; Sectoral unemployment; Current account.

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1 Introduction

According to the conventional wisdom, trade liberalization and productivity shocks biased toward the traded sector should be followed by intersectoral labor shifts. Labor reallocation would in turn gradually arbitrage away spatial and sectoral differences in wages. However, empirical findings cast doubt over the assumption of perfect labor mobility. Wacziarg and Wallack [2004] find that trade liberalization leads to little or no inter-industry worker reallocation, thus suggesting large switching costs across sectors. Only recently have researchers begun measuring mobility costs across sectors or regions. Adopting a structural empirical approach, Artuç et al. [2010], Dix-Carneiro [2014], Dix-Carneiro and Kovak [2017], Lee and Wolpin [2006] find substantial barriers of mobility and furthermore that wages are not equalized across sectors or regions neither in the short run nor in the long run. Despite the significance of limited labor mobility across sectors, only very few attempts have been made to investigate the consequences of technology shocks when workers experience costs of switching sectors. This analysis is all the more relevant that traded industries experience much larger productivity gains than non traded industries, thus leading to labor reallocation between sectors. While workers' mobility costs may hamper labor movements across sectors, labor market institutions which vary across countries also influence the shifts of employment and thus the sectoral output adjustment to technology shocks.

This paper proposes to disentangle quantitatively the implications of workers' mobility costs and labor market institutions for the relative price and the relative wage of non tradables responses to technology shocks biased toward the traded sector. While labor mobility costs are key to producing a sectoral wage differential in the long-run and mitigating the appreciation in the relative price, international differences in labor market regulation can account for the dispersion in sectoral wage and sectoral price differences across countries. The advantage to work on relative wage and relative price effects is that their movements estimated empirically can reveal the presence of labor market frictions.¹ Because such frictions in the labor market imply that hiring in the traded and non traded sector occurs at uneven paces, a key contribution of our paper is to show that higher relative productivity of tradables lowers the unemployment rate differential between tradables and non tradables in the long-run.

To set the stage of the quantitative analysis, we first assess empirically the effects of higher productivity in tradables relative to non tradables on both the relative wage and the relative price of non tradables. Our estimates reveal that a productivity differential between tradables and non tradables by 1% lowers the relative wage by 0.22% and appreciates the

¹The open economy version of the neoclassical model abstracting from labor market frictions predicts that the relative wage is unaffected while the relative price of non tradables appreciates by the same amount as the productivity differential, see e.g., Canzoneri et al. [1999], Kakkar [2003]. Contrasting empirically estimated effects on the relative wage and relative price with the baseline model's predictions allows us to gauge the presence of labor mobility costs whereas working on relative quantities could not give us such an information.

relative price by 0.64% for the whole sample. The long-run decline in the relative wage suggests the presence of labor market frictions preventing wage equalization across sectors. Such frictions can also rationalize the relative price appreciation which is less than that predicted by the standard neoclassical model abstracting from labor market frictions. A way to gauge the role of labor mobility costs is to investigate how vary the elasticities of the relative wage and the relative price over time and if their movements are positively related to the magnitude of labor reallocation caused by higher relative productivity. When estimating elasticities of the relative wage and relative price with respect to relative productivity on overlapping windows of fixed length, our estimates reveal that the former has been reduced over time by a factor of two, passing from -0.3 to -0.15, whilst the relative price appreciated significantly more. Strikingly, our estimates also show that the magnitude of labor reallocation across sectors following a productivity differential has almost doubled over the same period. These findings thus suggest that labor mobility costs have been reduced markedly which resulted in increases in relative wage and relative price elasticities with respect to relative productivity.

Whilst our evidence suggests that labor mobility costs can rationalize estimated effects of higher relative productivity of tradables, our empirical findings also reveal that international differences in labor market institutions can account for the cross-country dispersion in estimated effects. Using a set of indicators to capture the extent of labor market regulation, the decline in the relative wage is found empirically to be more pronounced and the appreciation in the relative price to be less in countries where the unemployment benefit scheme is more generous or the worker bargaining power measured by the bargaining coverage is larger. While the relative wage also falls more in countries where legal protection against dismissals is stricter, we find empirically that the relative price appreciates by a larger amount.

Labor market frictions are also empirically found to have major implications for the long-run adjustment in sectoral unemployment rates. Whilst higher relative productivity of tradables lowers the unemployment rate of tradables relative to that of non tradables for the whole sample as a result of labor mobility costs, our estimates also reveal that the decline in the relative unemployment rate of tradables is more pronounced in countries where labor markets are more regulated.

In order to account for our evidence, we put forward a variant of the two-sector open economy model with tradables and non tradables and search in the labor market along with an endogenous labor force participation decision in the lines of Shi and Wen [1999].² Like Alvarez and Shimer [2011], imperfect mobility across sectors arises because searching for a job in one sector is a time-consuming and thus a costly activity. In our model, the

²In contrast to Merz [1995], Andolfatto [1996], Shi and Wen [1999], Heer and Schubert [2012] who construct dynamic general equilibrium models with labor markets characterized by search frictions, we abstract from physical capital accumulation and consider a two-sector open economy setup.

elasticity of labor supply at the extensive margin plays a pivotal role because it measures the extent of workers' moving costs: the smaller the elasticity of labor supply, the larger the switching cost, and thus the lower the degree of labor mobility across sectors.³ Conversely, when we let the elasticity of labor supply tend toward infinity, the case of perfect labor mobility is obtained in the long-run so that the relative wage remains (almost) unaffected by productivity shocks biased toward the traded sector, in contradiction with our empirical findings. Standard search frictions are thus insufficient on their own to produce significant long-run movements in the relative wage. Conversely, as long as the elasticity of labor supply at the extensive margin takes intermediate values, the relative wage may fall. Because hiring is also a costly activity which depends on labor market institutions, the magnitude of the decline in the relative wage is determined by labor market regulation.

One key feature of our open economy model with search frictions is its dynamic nature. Because a productivity shock biased toward the traded sector leads to more hiring and the recruitment process is costly, it is optimal for the open economy to run a current account deficit along the transitional path. As the country must fulfill the intertemporal solvency condition, the trade balance must improve in the long-run. Higher net exports has an expansionary effect on the demand for tradables and thus on traded firms' hirings. If workers incur mobility costs, such demand shift lowers non traded wages relative to traded wages. It also mitigates the appreciation in the relative price of non tradables and thus the ability of non traded firms to compensate for lower productivity gains.⁴ As a result, the unemployment rate of tradables falls more than that of non tradables, in line with the evidence. The dynamic nature of our setup plays a pivotal role since keeping net exports fixed prevents the model from matching the evidence when traded and non traded goods are complements in consumption. With an elasticity of substitution between traded and non traded goods smaller than one, higher relative productivity of tradables increases the share of non tradables and thus has an expansionary effect on hirings in the non traded sector. As a result, the relative wage of non tradables increases instead of declining. Because the relative price appreciates more than the productivity differential, the unemployment rate differential between tradables and non tradables also increases instead of declining.

Importantly, when we calibrate our model to a representative OECD economy, our quantitative analysis reveals that our model can account for our aforementioned evidence. Even when traded and non traded goods are complements, the long-run increase in net

³We consider an endogenous sectoral labor force participation decision by assuming that representative household members experience disutility from working and searching efforts in each sector. Relocating hours worked from one sector to another is costly as the representative household must incur a searching cost for a job in this sector; such utility loss may capture sector-specific human capital and/or geographical mobility costs. Thus, in contrast to Matsuyama [1992] who assumes the irreversibility of the career decision, workers can move between sectors, at some cost though.

⁴This result echoes estimates by Lane and Milesi-Ferretti [2004] who find that countries with a larger decline in the net foreign position have more depreciated relative price of non tradables. In a world where labor market frictions are absent, the net foreign position would have no effect neither on the relative price, the relative wage nor the unemployment differential.

exports driven by the accelerated hiring process more than offsets the decline in the share of tradables so that the relative wage falls. Because the appreciation in the relative price is not large enough to offset lower productivity gains in the non traded sector, higher relative productivity of tradables drives down the unemployment rate differential between tradables and non tradables.

When exploring the impact of labor institutions, our sensitivity analysis reveals that more generous unemployment benefits or a higher worker bargaining power amplify the decline in both the relative wage and the relative unemployment rate of tradables and mitigate the appreciation in the relative price following a productivity differential, in line with our evidence. Intuitively, such labor market policies make firms' hiring in the traded sector more elastic to productivity gains and thus amplify the long-run rise in net exports which in turn exerts a larger negative impact on the relative wage of non tradables. Since the relative price appreciates less, unemployment of tradables falls more relative to that of non tradables. In addition, as firms' hiring in the non traded sector is less sensitive to productivity gains in countries where the firing cost is larger, stringent employment protection legislation causes the relative price to appreciate more, and both the relative wage and the relative unemployment rate of tradables to fall by a larger amount, in accordance with our empirical findings.

To assess the performance of the model and investigate the implications of labor market institutions for the cross-country dispersion in estimated effects, we calibrate the model to country-specific data. We thus allow for two pivotal sets of parameters which we estimate for each economy to vary across countries: search parameters and labor market policies which account for cross-country labor market differentials and the elasticity of substitution between tradables and non tradables. When we compare numerically computed responses of the relative wage and relative price to our empirical estimates for each OECD economy in our sample, we find that the model predicts the relative wage decline pretty well and to a lesser extent the rise in the relative price. Importantly, while the model generates a wide dispersion in the relative wage and the relative price responses across countries, we find quantitatively that it can account for the larger decline in the relative wage and the smaller appreciation in the relative price in countries where labor market regulation is more pronounced.⁵ Our cross-country analysis also reveals that a productivity differential of one percent results in a decline in the relative unemployment rate of tradables which appears to be insignificant in countries having more flexible labor markets, while the decrease ranges between twofold and fourfold of that obtained in the baseline case in economies with more regulated labor markets.

The remainder of the paper is organized as follows. In section 2, we provide empirical

⁵When using a measure of labor market regulation which encompasses the three dimensions of labor market institutions, we find that the relative price significantly appreciates less in countries where labor markets are more regulated.

facts on the effects of higher relative productivity of tradables suggesting the presence of labor mobility costs and document evidence on the implications of labor market regulation. In section 3, we develop an open economy version of the two-sector model with both imperfect mobility of labor arising from searching efforts and unemployment arising from matching frictions in both sectors. Section 4 sheds some light on the role of labor mobility costs and disentangles the implications of the three dimensions of labor market regulation. In section 5, we discuss numerical results. Section 6 summarizes our main results and concludes.⁶

Related literature. Our paper is at the cross-roads of three strands of the literature investigating the adjustment of open economies to structural shocks. First, it is closely related to the theory developed by Balassa [1964] and Samuelson [1964] which has been renewed recently, notably by Bergin et al. [2006], Ghironi and Melitz [2005], and Christopoulos et al. [2012]. The former two papers relax the assumption of perfectly competitive goods market and show that heterogenous productivity among firms and/or entry and exit of firms amplifies the effect of higher productivity in tradables relative to non tradables on domestic prices.⁷ In contrast, in our paper, we consider imperfectly competitive labor markets and show that labor market frictions moderate the appreciation in the relative price of non tradables following a productivity differential between tradables and non tradables by reducing the relative wage of non tradables. In this regard, Cardi and Restout [2015] show that imperfect mobility of labor across sectors is key to producing an elasticity of the relative price with respect to the productivity differential smaller than one. However, the paper abstracts from search frictions and thus neither addresses the role of labor market institutions nor the adjustment in sectoral unemployment rates. One of the main contributions of the present paper is to show both empirically and numerically that search frictions on workers' side are key to producing a decline in the relative wage along with the less than proportional increase in the relative price while international differences in labor market regulation account for the cross-country dispersion in both the relative wage and relative price responses. In this respect, our work complements that by Christopoulos et al. [2012] who put forward financial frictions as an explanation of the cross-country dispersion in the relative price movements. Unlike the aforementioned papers which abstract from search frictions, we show that the relative price adjustment to higher relative productivity plays a pivotal role in determining the magnitude of the decline in sectoral unemployment rates.

Second, our study can be viewed as complementary to the growing literature which

⁶An online technical appendix, available at <http://cred.u-paris2.fr/cardi>, provides a very detailed description of the dataset along with additional empirical results, and contains all the proofs and derivations of analytical results.

⁷Ghironi and Melitz [2005] show that higher traded productivity triggers firm entry which stimulates labor demand, raises wages and thus increases traded prices, amplifying the rise in domestic prices commonly induced by the appreciation in the price of non traded goods. According to Bergin et al. [2006], higher productivity in tradables relative to non tradables induces the least productive firms in the traded sector to cease exporting; as a result, the share of non tradables in the economy increases, thus amplifying the effect of the appreciation in the relative price of non tradables on domestic prices.

investigates the quantitative implications of barriers of mobility following trade shocks, e.g., Kambourov [2009] and Cosar [2013]. Developing and calibrating general equilibrium sectoral models of a small open economy with sector specific human capital, both Kambourov [2009] and Cosar [2013] find that human capital is a substantial barrier mobility along with firing costs for the former and search frictions for the latter. Like the authors, we uncover the factors that affects sectoral reallocation. In our setup, job search costs hamper labor reallocation, whilst labor market institutions may mitigate or amplify labor shifts across sectors. More precisely, by raising the marginal benefit of search, a more generous unemployment benefit scheme or a higher worker bargaining power encourages workers to shift from one sector to another. In contrast, in countries where firing costs are more pronounced, the shifts of labor are lower because firms are less prone to post more job vacancies. However, both our objective and modelling strategy are very different from those by Kambourov [2009] and Cosar [2013]. We abstract from workers' heterogeneity and rather emphasize the importance of various dimensions of labor market regulation in explaining cross-country differences in estimated effects of higher relative productivity. While we base most of our analysis on the long-run effects of a productivity differential, by keeping our setup simple enough, we are able to fully characterize analytically the transitional adjustment of the open economy toward the steady-state, focusing mainly on the dynamics of sectoral unemployment rates.⁸ Moreover, instead of considering sector-specific human capital, we generate imperfect mobility of labor by assuming that workers must search for a job before shifting from one sector to another, in the lines of Alvarez and Shimer [2011]. This modelling strategy enables us to derive analytical expressions for the response of the unemployment differential between tradables and non tradables to higher relative productivity of tradables. In this regard, our analysis is related to that by Curuk and Vannoorenberghe [2017] who derive analytical expressions of industry's employment to aggregate shocks. In contrast to them, we consider a model with search frictions and thus are interested in sectoral unemployment rates' adjustment and emphasize the implications of international differences in labor market regulation. Unlike the aforementioned papers, we show that the shift in the demand of goods and services along with the change in the net foreign asset position play a key role in determining the size and the direction of the effects of a technology shock.

The dynamic nature of our model along with time-varying net foreign asset position along the transitional path makes our setup very different from that constructed by Dutt, Mitra and Ranjan [2009] who analyze the effects of trade openness on unemployment by assuming that trade is balanced. In our model, the share of tradables varies as the result of imperfect substitutability between tradables and non tradables and net exports'

⁸While we employ 'long-run' to refer to steady-state values, it refers to a medium-run analysis as we abstract from physical capital and we find numerically that the adjustment is rapid since it takes the open economy between 3 and 5 years to reach the steady-state.

adjustment. Most importantly, our model allows for an endogenous sectoral labor force participation decision which produces intersectoral mobility costs; such a feature enables us to rationalize the responses we document empirically. Moreover, in addition to providing analytical results, we solve the model numerically.

Third, like the literature employing multi-sector model with search frictions in the labor market, we emphasize that sectoral shocks that hit the economy unevenly produce short-run effects which are quite distinct from those prevailing in the long-run. More specifically, Phelan and Trejos [2000] show that an adverse sectoral demand shock originating from a cut in military purchases can be greatly magnified as a result of the combined effect of labor shifts across sectors and a slow reallocation. The gradual adjustment in sectoral labor plays also a key role in our model as the long-run effects are reversed in the short-run. While in the long-run, an increase in relative productivity of tradables lowers the unemployment rate of tradables relative to that of non tradables, we get the opposite result on impact. When the shock hits the economy, the unemployment rate of non tradables falls dramatically as a result of the combined effect of the positive wealth effect along with the sector-biased technology shock. Unlike Phelan and Trejos [2000], changes in sectoral demand occur endogenously in our model. Moreover, the present paper endogenously generates workers' costs of switching sectors caused by job search costs and differentiate their implications from those driven by hiring costs supported by firms which are influenced by labor market institutions. One close paper to ours is Chang [2012] who develops a two-sector model with search frictions and emphasizes the key role of the combined effect of standard search frictions and imperfect mobility of labor following sectoral TFP shocks biased toward one sector. However, our work differs in many respects. First, Chang [2012] formalizes the mobility decision such that the switching cost vanishes in the long-run whereas we consider that workers experience a mobility cost at the steady-state in line with our evidence which reveals that the sectoral wage differential is persistent in the long-run. Second, we consider an open economy where both consumers' preferences and the dynamics of the net foreign asset position play a pivotal role in determining the long-run effects. These features are absent from Chang's setup. Third, we perform a cross-country quantitative analysis. Fourth, a rise in relative productivity produces quantitatively much greater unemployment effects in our setup since the aggregate labor force is not constant as we allow for the transition between leisure and the labor force, in accordance with the Real Business Cycle literature.

2 Empirical Facts

In this section, we document a set of empirical facts related to the effects of higher productivity in tradables relative to non tradables and investigate how labor market frictions shape estimated effects. We denote the level of the variable in upper case, the logarithm in lower case (except for the unemployment rate which is expressed in percentage point), and

the percentage deviation from its initial steady-state by a hat.

2.1 A Simple Model with Labor Market Frictions

To set the stage for the empirical analysis, we revisit the theory that Balassa [1964] and Samuelson [1964] (BS hereafter) developed by relaxing the assumption of perfectly competitive labor markets in order to build up intuition regarding the implications of labor market frictions. As it is commonly assumed, the country is small in terms of both world goods and capital markets, and thus faces an exogenous international price for the traded good normalized to unity. Each sector produces Y^j by using labor, L^j , according to a linear technology, $Y^j = A^j L^j$, where A^j represents the labor productivity index.

Because firms face a cost by maintaining job vacancies, they receive a surplus equal to the marginal revenue of labor Ξ^j less the product wage W^j . Symmetrically, so as to compensate for the cost of searching for a job, unemployed workers receive a surplus equal to W^j less the reservation wage W_R^j . We denote by Ψ^j the overall surplus created when a job-seeking worker and a firm with a job vacancy conclude a contract:

$$\Psi^j = \Xi^j - W_R^j(\theta^j), \quad (1)$$

where $\Xi^T = A^T$, $\Xi^N = PA^N$ with P corresponding to the relative price of non tradables, and we denote by θ^j the labor market tightness in sector j , defined as the ratio of job vacancies to unemployed workers; when firms post more job vacancies, θ^j rises which raises the reservation wage, i.e., $\hat{w}_R^j = \chi^j \hat{\theta}^j$ where $0 < \chi^j < 1$ represents the share of the surplus associated with a labor contract in the marginal benefit of search.

The product wage W^j paid to the worker in sector j is equal to the reservation wage plus a share α_W of the overall surplus:

$$W^j = W_R^j(\theta^j) + \alpha_W \Psi^j, \quad (2)$$

where the worker bargaining power α_W is assumed to be symmetric across sectors. Denoting the relative wage by $\Omega \equiv W^N/W^T$ and differentiating (2) leads to the sectoral wage differential:

$$\hat{\omega} \equiv \hat{w}^N - \hat{w}^T = -\frac{\chi W_R}{W} (\hat{\theta}^T - \hat{\theta}^N) - \frac{\alpha_W \Psi}{W} (\hat{\Psi}^T - \hat{\Psi}^N), \quad (3)$$

where we assume that initially $W^j \simeq W$ and $\chi^j W_R^j \simeq \chi W_R$ and $\Psi^j \simeq \Psi$ to ease the interpretation. In a model abstracting from labor market frictions, as the standard BS model, searching for a job is a costless activity so that Ψ and χ are nil; hence sectoral wages rise at the same speed. Conversely, in a model with labor market frictions, a productivity differential between tradables and non tradables may lower ω . The reason is as follows. First, as captured by the first term on the RHS of (3), higher A^T/A^N induces traded firms to recruit more than non traded firms; because agents experience a utility loss when increasing the search intensity for a job in the traded sector, traded firms must increase

wages to attract workers as reflected by the rise in the ratio θ^T/θ^N . Moreover, as shown by the second term on the RHS of (3), by raising Ψ^T/Ψ^N , a productivity differential between tradables and non tradables lowers ω ; intuitively, higher A^T/A^N increases the surplus from an additional job in the traded sector relative to the non traded sector, Ψ^T/Ψ^N , the worker obtaining a share equal to α_W .

Denoting the job destruction rate by s^j and the job finding rate by m^j , and using the fact that at the steady-state, the flow of unemployed workers who find a job is equalized with the flow of employed workers who lose their job, the unemployment rate u^j in sector j reads as $u^j = \frac{s^j}{s^j + m^j(\theta^j)}$. Totally differentiating u^j and denoting the elasticity of vacancies in job matches by α^V , allows us to express the unemployment rate differential between tradables and non tradables in terms of the differential in sectoral labor market tightness:

$$du^T - du^N = -\alpha^V u(1-u) (\hat{\theta}^T - \hat{\theta}^N), \quad (4)$$

where we assume that at the initial steady-state, search parameters are such that $u^j \simeq u$. According to (4), higher A^T/A^N results in a decline in u^T relative to u^N by raising the ratio θ^T/θ^N as traded firms recruit more than non traded firms.

When a labor contract is concluded with a worker, the representative firm in sector j receives the marginal revenue of labor Ξ^j which must cover the recruiting cost plus the dividend per worker equivalent to $(1 - \alpha_W) \Psi^j$ and the wage rate paid to the worker:

$$\Xi^j = (1 - \alpha_W) \Psi^j + W^j. \quad (5)$$

Differentiating (5) and subtracting $\hat{\Xi}^T$ from $\hat{\Xi}^N$ leads to:

$$\hat{p} = (\hat{a}^T - \hat{a}^N) + \frac{W}{\Xi} (\hat{w}^N - \hat{w}^T) - \frac{(1 - \alpha_W) \Psi}{\Xi} (\hat{\Psi}^T - \hat{\Psi}^N), \quad (6)$$

where we assume that initially $\Xi^j \simeq \Xi$, $\Psi^j \simeq \Psi$, and $W^j \simeq W$. According to (6), when abstracting from labor market frictions, as the BS model, the surplus Ψ is nil while sectoral wages increase at the same speed so that p must appreciate by the same amount as $\hat{a}^T - \hat{a}^N$. Conversely, in a model with labor market frictions, as captured by the second term on the RHS of (6), ω falls because traded firms have to pay higher wages to compensate for the workers' mobility costs. Moreover, as shown by the third term on the RHS of (6), since traded firms recruit more than non traded firms, the hiring cost must be covered by an increase in Ψ^T/Ψ^N , the firm obtaining a share equal to $1 - \alpha_W$. Thus, by lowering ω and increasing the hiring cost in the traded sector relative to that in the non traded sector, a productivity differential of 1% appreciates p by less than 1%.

The relative wage and relative price equations described by (3) and (6), respectively, allow us to explain why labor market frictions imply that sectoral wages may no longer rise at the same speed and the elasticity of the relative price w.r.t. the productivity differential may be smaller than one. However, such conclusions are established by abstracting from

the goods market equilibrium which matters as long as labor is not perfectly mobile across sectors. In section 4, we show that the full steady-state can be solved for the relative price and the relative wage, i.e., $P \equiv P^N/P^T = P(A^T, A^N)$ and $\Omega \equiv W^N/W^T = \Omega(A^T, A^N)$. Because all variables display trends, our empirical strategy consists in estimating the cointegrating relationships with relative productivity.

In the following, we also explore empirically whether higher A^T/A^N leads to $du^T - du^N < 0$. Whilst the standard BS model abstracting from labor market frictions cannot address unemployment issues, standard search frictions are not sufficient on their own to lower the unemployment rate differential following a rise in A^T/A^N . More specifically, for higher relative productivity to result in a decline in u^T relative to u^N , as shown in eq. (4), traded firms must recruit more than non traded firms. For this to happen, the appreciation in the p must be less than the productivity differential otherwise non traded firms are able to exactly offset lower productivity gains by setting higher prices. As discussed above, the relative price appreciates less than proportionately if workers experience mobility costs.

2.2 Data Construction

Before empirically exploring the effects of higher relative productivity, we briefly describe the dataset we use and provide details about data construction below and in Appendix A. Our sample consists of a panel of eighteen OECD countries for eleven 1-digit ISIC-rev.3 industries. To split these eleven industries into traded and non traded sectors, we follow the classification suggested by De Gregorio et al. [1994] that we updated by following Jensen and Kletzer [2006].

For the relative price and the relative wage, our sample covers the period 1970-2007. We use the EU KLEMS [2011] database which provides domestic currency series of value added in current and constant prices, labor compensation and employment (number of hours worked) for each sector j (with $j = T, N$), permitting the construction of price indices p^j (in log) which correspond to sectoral value added deflators, sectoral wage rates w^j (in log), and sectoral measures of productivities a^j (in log). The relative price of non tradables at time t in country i , $p_{i,t}$, is the log of the ratio of the non traded value added deflator to the traded value added deflator (i.e., $p_{i,t} = p_{i,t}^N - p_{i,t}^T$). The relative wage $\omega_{i,t}$ is the log of the ratio of the non traded wage to the traded wage (i.e., $\omega_{i,t} = w_{i,t}^N - w_{i,t}^T$). We use sectoral labor productivities $A_{i,t}^j = Y_{i,t}^j/L_{i,t}^j$ to approximate technical change which are constructed from constant-price series of value added $Y_{i,t}^j$ and hours worked $L_{i,t}^j$.

We construct time series for sectoral unemployment rate, u^j , as the ratio of the number of unemployed workers U^j in sector j to the labor force $F^j \equiv L^j + U^j$ in this sector. Data are taken from LABORSTA database from ILO which provides series for unemployed workers by economic activity for fourteen OECD countries out of eighteen listed in Appendix A. The longest available period ranges from 1987 to 2007. On average, our data covers thirteen

years per country (see Appendix B.3).⁹

2.3 Estimating the Effects of Higher Relative Productivity

We regress the (log) relative wage ω and the (log) relative price p on the (log) relative productivity, respectively:¹⁰

$$\omega_{i,t} = \delta_i + \beta \cdot (a_{i,t}^T - a_{i,t}^N) + v_{i,t}, \quad (7a)$$

$$p_{i,t} = \alpha_i + \gamma \cdot (a_{i,t}^T - a_{i,t}^N) + u_{i,t}, \quad (7b)$$

where i and t index country and time and $v_{i,t}$ and $u_{i,t}$ are i.i.d. error terms. Country fixed effects are captured by country dummies δ_i and α_i .

Since p , ω and $a^T - a^N$ display trends, we ran unit root and then cointegration tests. Having verified that these two assumptions are empirically supported, we estimate the cointegrating relationships by using fully modified OLS (FMOLS) and dynamic OLS (DOLS) procedures for the cointegrated panel proposed by Pedroni [2000], [2001]. Both estimators give similar results and coefficients β and γ of the cointegrating relationships are significant at 1%. Two major results emerge. First, estimates reported in the Table 1 reveal that a productivity differential between tradables and non tradables by 1% lowers the relative wage by about 0.22% and appreciates the relative price by 0.64%. Second, as shown in the second line and the third line of Table 1, the predictions of the model abstracting from labor market frictions are strongly rejected: the slope of the cointegrating vector β (γ) is statistically significantly different from zero (one).

We now assess if our conclusion for the whole sample also holds for each country. To do so we run again the regression of relative wage and relative price on relative productivity by letting β and γ vary across countries. Table 2 shows DOLS and FMOLS estimates for the eighteen countries of our sample. The first result that emerges is that the responses display a wide dispersion across countries. The second result is that despite these large cross-country variations, higher productivity in tradables relative to non tradables significantly lowers ω in all countries while p rises less than the productivity differential.

Because long-run movements in both the relative wage and relative price reveal the presence of labor market frictions, we also run the regression of the change in the unemployment rate differential between tradables and non tradables on the relative productivity

⁹Whereas we are able to construct time series of sectoral unemployment rates for Korea, data for the unemployment benefit replacement rate, used as a control variable, are not available before 2002 and thus this country is removed from the sample.

¹⁰In contrast to Kakkar [2003], Cardi and Restout [2015] who do not identify empirically the role of labor market institutions following a productivity differential, our dataset includes eighteen OECD countries instead of fourteen and we measure technological change with sectoral labor productivity instead of sectoral TFP in order to be consistent with the model developed in section 3 where we abstract from physical capital accumulation. It is worth mentioning that the two-sector open economy model with search frictions we develop is tractable enough to enable us to derive analytical expressions of elasticities β , γ (see section 5.3) and σ (see section 5.4) estimated empirically.

of tradables in growth rate:¹¹

$$du_{i,t}^T - du_{i,t}^N = \eta_i + \sigma \cdot (\hat{a}_{i,t}^T - \hat{a}_{i,t}^N) + z_{i,t}, \quad (8)$$

where η_i are the country fixed effects and $z_{i,t}$ are i.i.d. error terms. As can be seen in the first line of Table 3, a rise in the productivity differential by 1% lowers the unemployment rate in the traded relative to the non traded sector by 0.034 percentage point. Columns 2 to 4 reveal that our result is robust to the inclusion of control variables for labor market regulation and thus sectoral unemployment rates adjust unevenly in all specifications.¹²

< [Please insert Tables 1, 2 and 3 about here](#) >

2.4 How to Explain Estimated Effects?

As stressed in section 2.1, the decline in the relative wage following higher relative productivity points the presence of labor market frictions which are responsible for the less than proportional appreciation in the relative price along with the significant fall in u^T relative to u^N .

While the causes of labor market frictions hampering labor reallocation are diverse, they can be classified into two categories: those related to the workers' characteristics, thus affecting labor supply, and those related to rigid labor markets influencing firms' labor demand. The present paper endogenously generates workers' costs of switching sectors caused by job search costs and differentiate their implications from those driven by hiring costs supported by firms which are influenced by labor market institutions.¹³ Like Alvarez and Shimer [2011], workers experience mobility costs as they have to search for a job before switching from one sector to another.¹⁴ Intuitively, because searching for a job is time-consuming, such an activity is costly in utility terms. As a result, following higher productivity of tradables relative to non tradables, traded firms have to pay higher wages in order to compensate for the workers' costs of switching. Hence, the relative wage of non tradables must fall. Because non traded wages increase less rapidly than traded wages, mobility costs mitigate the appreciation in the relative price of non tradables (see eq. (6)). Since higher prices of non traded goods are not high enough to even lower relative

¹¹Since series for the unemployment rate differential do not display a unit root process, we express the labor productivity in growth rate. Moreover, on average, the time horizon is too short to recourse to cointegration techniques.

¹²In the second (third) column of Table 3, we include employment protection legislation adjusted with the share of permanent workers (unemployment benefit replacement rate) since these variables are available for a yearly basis. The fourth column shows that results are unchanged when we add two control variables.

¹³A convenient shortcut to generate workers' mobility costs is to assume limited substitutability in hours worked across sectors along the lines of Horvath [2000]. Adopting this modelling strategy and calibrating an open economy version of the neoclassical model with tradables and non tradables, Cardi and Restout [2015] find that limited labor mobility is key to generating a less than proportional appreciation in the relative price following a 1% increase in the productivity of tradables relative to non tradables. Beyond the fact that the causes of workers' mobility costs remain unexplained, by abstracting from search frictions, the authors cannot address the implications of labor market institutions.

¹⁴From the worker point of view, the mobility costs can be interpreted as psychological costs when switching from one sector to another (see e.g., Dix-Carneiro [2014]), geographic mobility costs (see e.g., Kennan and Walker [2011]) or can be the result of sector-specific human capital (see e.g., Lee and Wolpin [2006]).

productivity gains out, traded firms' hire more which results in a larger decline in the unemployment rate in tradables relative to that in non tradables.

A way to gauge the role of labor mobility costs in determining the adjustment of the economy to a productivity differential is to investigate whether elasticities β , γ , and σ (see (7a)-(8)) vary over time and explore their relationship with the extent of labor reallocation across sectors triggered by higher relative productivity. To perform this experiment, we estimate β , γ , and σ in rolling sub-samples. To check results' robustness, we consider different windows' lengths.¹⁵ As can be seen in the first row of Figure 1 which reports the elasticity of the relative wage to relative productivity (i.e., β) in the solid black line, for all windows' lengths, the response of ω has increased over time (i.e., β becomes less negative). One obvious candidate to explaining such an increase in β is the decline in labor mobility costs. If workers incur lower costs of switching sectors, then a productivity differential would result in a greater reallocation of labor between the traded and the non traded sector.¹⁶ As it clearly stands out, the estimated response of the relative wage tends to increase over time, especially in the nineties, and such a pattern is associated with more labor reallocation following higher relative productivity, in line with our hypothesis. The second row of Figure 1 reveals that as more workers shift from one sector to another following higher productivity gains in tradables relative to non tradables, the relative price appreciates more over time (until the beginning of 2000's), i.e., γ takes higher values. Focusing on panels 1(a) and 1(d), the magnitude of labor reallocation reaches a peak at the beginning of 2000's and then tends to be declining. Such a pattern tracks pretty well the fall in γ from 2002 onwards and to a lesser extent the merely declining path of β which starts later, in 2005. Another piece of evidence which corroborates the role of labor reallocation in shaping the labor market adjustment is the increase in σ which captures the response of the unemployment differential to a rise in relative productivity, as can be seen in Figure 1(f).¹⁷

< Please insert Figure 1 about here >

¹⁵When estimating β and γ , we run the same regression as in eqs. (7a)-(7b), except that we consider overlapping subperiods of different fixed lengths, i.e., $T = 20$, $T = 25$, $T = 30$ years. More specifically, for $T = 20$, we estimate eqs. (7a)-(7b) over 1970-1990, 1971-1991, ..., 1987-2007, for $T = 25$, over 1970-1995, ..., 1982-2007, and for $T = 30$, 1970-2000, ..., 1977-2007. To save space, we do not show the results for the relative price when $T = 30$.

¹⁶Following Wacziarg and Wallack [2004], we compute the labor reallocation index in year t for country i denoted by $LR_{i,t}$ by calculating the rate of workers that have shifted from one sector to another over τ years:

$$LR_{i,t}(\tau) = \frac{\sum_{j=T}^N |L_{i,t}^j - L_{i,t-\tau}^j| - \left| \sum_{j=T}^N L_{i,t}^j - \sum_{j=T}^N L_{i,t-\tau}^j \right|}{0.5 \sum_{j=T}^N (L_{i,t-\tau}^j + L_{i,t}^j)} \quad (9)$$

where $\tau = 5$ and $L_{i,t}^j$ denotes employment in sector $j = T, N$. To estimate the effect of higher relative productivity on labor reallocation, we run the following regression in rolling sub-samples:

$$LR_{i,t} = \zeta_i + \chi \cdot (\hat{a}_{i,t}^T - \hat{a}_{i,t}^N) + \nu_{i,t}.$$

Since the labor reallocation index is stationary, relative productivity is expressed in growth rate.

¹⁷When running the regression of the unemployment differential on relative productivity of tradables in growth rate, we add unemployment benefit replacement as a control; due to data availability, we consider one unique window's length (i.e., $T = 12$) and exclude BEL, DNK, JPN, USA as the time horizon for sectoral unemployment data taken from ILO is too short for these countries.

While above evidence suggests that workers' mobility costs matter in producing a decline in non traded wages relative to traded wages following higher relative productivity of tradables, our estimates also show that the size of the decline in the relative wage varies greatly across countries. Since labor market institutions influence the elasticity of hiring with respect to productivity gains, international differences in labor regulation could be responsible for the cross-country dispersion in the decline in the relative wage. Moreover, by determining the extent of hirings and thus output changes within each sector, the degree of labor market regulation should affect the extent of the decline in the relative unemployment rate of tradables along with the magnitude of the appreciation in the relative price of non tradables following a productivity differential.

As will be clear later when we will further develop the transmission mechanism, labor market regulation influences goods and labor market variables through two distinct channels according to the type of labor market institutions:

- First, we expect the traded wage to increase more and the relative price of non tradables to appreciate less in countries where unemployment benefits are more generous or workers have a larger bargaining power.¹⁸ As a result, these economies should also experience a larger decline in the unemployment rate of tradables.
- Second, we conjecture that in countries with higher firing costs, the non traded wage should rise less, the unemployment rate of non tradables should decrease by a smaller amount and the relative price should appreciate more.¹⁹

2.5 Labor Market Regulation and Cross-Country Differences

We consider three dimensions of labor market regulation:

- The first aspect is the difficulty of redundancy that we measure by the employment protection legislation (EPL hereafter) index provided by the OECD; this index which captures the strictness of legal protection against dismissals for permanent workers has the advantage to be available for all countries of our sample over the period 1985-2007. In order to have a more accurate measure of the difficulty of redundancy, we adjust EPL for regular workers with the share of permanent workers in the economy

¹⁸Intuitively, as these economies display a low labor market tightness, hiring is more profitable following productivity gains because it is easier to fulfill job vacancies. As will be detailed subsequently, a larger increase in hirings in the short-run leads a higher rise in net exports in the long-run. Higher demand for tradables tends to mitigate the appreciation in the relative price caused by a productivity differential. Because labor demand in the traded sector is more elastic to productivity gains in countries where the replacement rate or the worker bargaining power is higher, the traded wage is expected to increase by a larger amount. Because traded firms recruit more, u^T will decline by a larger amount.

¹⁹Because a productivity shock tends to lower aggregate labor supply through the positive wealth effect while the non traded sector experiences relatively low productivity gains, the shrinking non traded establishments are subject to the redundancy cost. As a result, they are less prone to recruit more workers when productivity increases. Labor demand in the non traded sector is thus less elastic to productivity gains in countries where employment protection is more pronounced, which mitigates increases in w^N and the decline in u^N . Since traded output increases more relative to non traded output, we expect p to appreciate by a larger amount.

(see Boeri and Van Ours [2008]). The indicator is denoted by EPL_{adj} .

- The generosity of unemployment benefit systems is measured by using the replacement rate, denoted by ρ . The data we use are taken from the OECD database which calculates the average of the net unemployment benefit for three durations of unemployment (1st year, 2nd and 3rd year, 4th and 5th year).
- In the empirical literature, the worker bargaining power is commonly captured by the bargaining coverage; we thus use this indicator, denoted by $BargCov$, which gives the proportion of employees covered by collective bargaining. Data are taken from the ICTWSS database (Visser [2009]).

To empirically explore our conjecture according to which the relative wage falls more following a productivity differential between tradables and non tradables in countries with more regulated labor market, we perform a simple split-sample analysis. Hence, we compare the relative wage behavior of 9 countries with high and 9 economies with low labor market regulation by running the regression (7a) of ω on relative productivity for each sub-sample. We thus expect β^H , which captures the response of ω to a productivity differential in countries with higher labor market regulation, to be larger (in absolute terms) than β^L which reflects the reaction of ω in countries with lower labor market regulation. Because labor market regulation influences the magnitude of responses of labor to productivity gains, labor market institutions should affect the extent of the appreciation in p . Adopting the same strategy than that for ω , we run the regression (7b) of the relative price on relative productivity for each sub-sample.²⁰ More specifically, we investigate whether p appreciates more in countries with stricter legal protection against dismissals (i.e., we expect $\gamma^H > \gamma^L$) and increases less in countries with more generous unemployment benefit scheme or a higher worker bargaining power (i.e., we expect $\gamma^H < \gamma^L$).

The DOLS and FMOLS estimates are reported in Table 4 for countries with high and low labor market regulation. The last two lines of Table 4 gives the sub-sample's average of the corresponding labor market regulation index. As the results in panel A of Table 4 show, the decline in the relative wage is significantly greater for countries with more regulated labor markets, i.e., $|\beta^H| > |\beta^L|$. While countries providing lower unemployment benefits experience a decline in ω of -0.16% approximately, the second set of countries with generous unemployment benefits experience a fall in ω of -0.26%. Furthermore, as shown in the second column of Table 4, ω falls by -0.24% in countries where the worker bargaining power is relatively higher instead of -0.18% in economies with a lower bargaining coverage. A similar pattern emerges when we exploit a third dimension of labor market regulation, namely the strictness of employment protection. Since series for EPL are available over

²⁰Because the movements in p can be influenced by changes in the cost of entry in product market triggered by competition-oriented policies, we add country-specific linear time trends when we run the regression (7b) for each sub-sample in order to control for these effects.

1985-2007, we run again the regression (7a) for each sub-sample over this period to be consistent. We find that ω declines by 0.17% in countries with higher firing costs while ω declines by only 0.13% in the second set of countries. Because labor market regulation includes three indicators, we have recourse to a principal component analysis in order to have one overall indicator reflecting all the dimensions of labor market institutions. As displayed in the last column of Table 4, we find that countries with more regulated labor markets experience a larger decline in ω . Finally, we detect a significant difference in the responses of the relative wage between countries with low and high labor market regulation as shown in the third line of Table 4 which indicates that imposing the restriction $\beta^L = \beta^H$ is strongly rejected at a 1% significance level.

< Please insert Table 4 about here >

Turning to the relative price, the first two columns of panel B of Table 4 show that higher productivity in tradables relative to non tradables causes an appreciation in p which is significantly smaller in countries with more generous unemployment benefits or a higher bargaining coverage. Conversely, as displayed in the third column of Table 4, stricter employment protection legislation tends to amplify the increase in p , in line with our conjecture. However, the difference in the relative price responses caused by firing costs between the two sub-samples is not statistically significant. Because EPL_{adj} does not seem to exert substantial effects on the relative price responses to a productivity differential, it is thus not surprising to find that labor market regulation tends to mitigate the appreciation in p as shown in the last column of Table 4. As discussed later, this finding is in line with our quantitative results which show that large differences in employment protection legislation do not cause marked differences in the relative price adjustment following a productivity differential, the cross-country dispersion in the relative price responses being mostly driven by differences in unemployment benefit replacement rates.

To explore the implications of labor market regulation for the response of the unemployment rate differential, we split our sample into groups with less and more regulated labor markets by using the mean value of the index which encompasses the three dimensions of labor market regulation. Our analysis covers 14 countries out of which 8 are classified as countries with more regulated labor markets.²¹ Contrasting estimates of σ^H with those of σ^L shown in the second and third line of Table 3, respectively, a rise in the relative productivity of tradables drives down the relative unemployment rate of tradables, and more so in countries where labor market regulation is higher. More specifically, the unemployment rate of tradables relative to that of non tradables declines by 0.033 and 0.036 ppt in economies

²¹Because the effect of an increase in relative productivity of tradables on the unemployment rate differential is small since the latter variable is the difference between two sectoral ratios, we find it convenient to base the split-sample analysis on the mean value instead of the median as we obtain more clear-cut results in this case. In a Technical Appendix, we show that whether we use the median or the mean sample, our split-sample analysis is robust to the threshold used when we explore the implications of three dimensions of labor market regulation for the relative wage and relative price effects of a productivity differential.

with less and more regulated labor markets, respectively. Subsequent columns show that estimated effects between the two subsamples are more distinct; when controlling for the replacement rate and employment protection, the unemployment rate differential falls by 0.032 and 0.041 ppt in countries with low and high labor market regulation, respectively.

In the following, we develop a dynamic general equilibrium model by allowing for search frictions which have two distinct dimensions and assess its ability to account for our evidence. The first cause of search frictions is related to the costs supported by workers when they wish to shift hours worked from one sector to another. We explore the ability of such mobility costs to mitigate the appreciation in p and lower both ω and the unemployment rate differential $u^T - u^N$ in line with our evidence. The second cause of search frictions relates to the costs supported by firms when they wish to hire workers. Such costs are influenced by labor market institutions which vary substantially across countries. We investigate whether countries with more regulated labor markets experience a larger decline in both the relative wage and the relative unemployment rate of tradables, and a smaller appreciation in the relative price of non tradables in accordance with our empirical findings.

3 The Framework

The country is small in terms of both world goods and capital markets, and faces a given world interest rate, r^* .²² The small open economy is populated by a constant number of identical households and firms that have perfect foresight and live forever. Households decide on labor market participation and consumption while firms decide on hirings. The economy consists of two sectors. One sector produces a traded good denoted by the superscript T that can be exported while the other sector produces a non-traded good denoted by the superscript N . The setup allows for traded and non-traded goods to be used for consumption. The traded good is chosen as the numeraire. The labor market, in the tradition of Diamond-Mortensen-Pissarides, consists of a matching process within each sector between the firms who post job vacancies and unemployed workers who search for a job. Time is continuous and indexed by t .²³

3.1 Households

At each instant the representative agent consumes traded goods, $C^T(t)$, and non-traded goods, $C^N(t)$, which are aggregated by a constant elasticity of substitution function:

$$C(C^T(t), C^N(t)) = \left[\varphi^{\frac{1}{\phi}} (C^T(t))^{\frac{\phi-1}{\phi}} + (1 - \varphi)^{\frac{1}{\phi}} (C^N(t))^{\frac{\phi-1}{\phi}} \right]^{\frac{\phi}{\phi-1}}, \quad (10)$$

²²The price of the traded good is determined on the world market and exogenously given for the small open economy. Hence, real exchange rate movements are exclusively caused by the long-run adjustment in the relative price of non tradables.

²³Our paper builds on Heijdra and Ligthart [2009]. Unlike the authors, we consider a two-sector framework where the sectoral elasticity of labor supply at the extensive margin determines the transition between the traded and the non traded sector labor force and we explore the implications of labor market regulation.

where φ is the weight of the traded good in the overall consumption bundle ($0 < \varphi < 1$) and ϕ is the intratemporal elasticity of substitution ($\phi > 0$).

The economy that we consider consists of a representative household with a measure one continuum of identical infinitely lived members. At any instant, members in the household derive utility from consumption goods C and experience disutility from working and searching efforts. More precisely, the representative household comprises members who engage in only one of the following activities: working and searching a job in each sector, or enjoying leisure. Assuming that the representative individual is endowed with one unit of time, leisure is defined as $1 - F^T(t) - F^N(t)$, with $F^j(t)$ the labor force in sector $j = T, N$ defined as the sum of units of labor time, $L^j(t)$, and time spent on searching for a job in sector j , $U^j(t)$, i.e., $F^j(t) = L^j(t) + U^j(t)$. Unemployed agents are randomly matched with job vacancies according to a matching function described later. Since the timing of a match is random, agents face idiosyncratic risks. To simplify the analysis, we assume that members in the household perfectly insure each other against variations in labor income.

Because the labor force is not constant, we allow for the transition between employment and unemployment and the transition between leisure and labor force. Since the labor force in sector j is not constant as well, we allow for the transition between the traded and the non traded sector. More specifically, we consider that the utility function is additively separable in the disutility received by working and searching in the two sectors. Such a specification makes it impossible to switch from one sector to another instantaneously without going through a spell of search unemployment, as in Alvarez and Shimer [2011]. This can be justified on the grounds of sector-specific skills as well as geographical or psychological mobility costs. The representative household chooses the time path of consumption and labor force to maximize the following objective function:

$$\Upsilon = \int_0^\infty \left\{ \frac{1}{1 - \frac{1}{\sigma_C}} C(t)^{1 - \frac{1}{\sigma_C}} - \frac{\zeta^T}{1 + \frac{1}{\sigma_L^T}} F^T(t)^{1 + \frac{1}{\sigma_L^T}} - \frac{\zeta^N}{1 + \frac{1}{\sigma_L^N}} F^N(t)^{1 + \frac{1}{\sigma_L^N}} \right\} e^{-\beta t} dt, \quad (11)$$

where $\zeta^j > 0$ parametrizes the disutility from working and searching efforts in sector $j = T, N$, $\beta > 0$ is the consumer's subjective time discount rate, and $\sigma_C > 0$ is the intertemporal elasticity of substitution for consumption; $\sigma_L^j > 0$ is the elasticity of labor supply at the extensive margin in sector $j = T, N$; it measures the extent of workers' moving costs: the smaller the elasticity of labor supply, the larger the utility loss when switching, and thus the lower the degree of labor mobility across sectors.²⁴ For later use, we denote by u^j the sectoral unemployment rate defined as $u^j(t) = U^j(t)/F^j(t)$.

Denoting by $m^j(t)$ the rate at which unemployed agents find jobs and s^j the exogenous rate of job separation, employment in sector j evolves gradually according to:

$$\dot{L}^j(t) = m^j(t)U^j(t) - s^j L^j(t). \quad (12)$$

²⁴Workers' switching costs are the result of an endogenous sectoral labor force participation decision which implies that the allocation of the labor force across sectors is elastic to the ratio of sectoral reservation wages.

Households supply $L^j(t)$ units of labor services in sector $j = T, N$ for which they receive the product wage $W^j(t)$. We denote by $A(t)$ the stock of financial wealth held by households which comprises internationally traded bonds, $B(t)$, and shares on domestic firms. Because foreign bonds and domestic shares are perfect substitutes, the stock of financial wealth yields net interest rate earnings $r^*A(t)$. Denoting by $T(t)$ the lump-sum taxes, the flow budget constraint is equal to households' real disposable income less consumption expenditure:

$$\dot{A}(t) = r^*A(t) + \sum_j W^j(t)L^j(t) + \sum_j R^j U^j(t) - T(t) - P_C(P(t))C(t), \quad (13)$$

where $P_C(P)$ is the consumption price index which is a function of the relative price of non tradables, P , and R^j represents unemployment benefits received by job seekers in sector j .

Denoting by $\lambda(t)$ and $\xi^j(t)$ the shadow prices of wealth and finding a job in sector j , respectively, the key equations characterizing optimal household behavior are:²⁵

$$C(t) = (P_C(t)\lambda(t))^{-\sigma_C} \quad (14a)$$

$$F^j(t) = \{\lambda(t) [m^j(\theta^j(t))\xi^j(t) + R^j] / \zeta^j\}^{\sigma_L^j}, \quad (14b)$$

$$\dot{\lambda}(t) = \lambda(t)(\beta - r^*), \quad (14c)$$

$$\dot{\xi}^j(t) = (s^j + r^*)\xi^j(t) - \left[W^j(t) - \frac{\zeta^j(F^j(t))^{1/\sigma_L^j}}{\lambda(t)} \right], \quad (14d)$$

and the appropriate transversality conditions. In order to generate an interior solution, we impose $\beta = r^*$; hence, (14c) implies that λ must remain constant over time, i.e., $\lambda(t) = \bar{\lambda}$. Eq. (14b) shows that labor market participation increases with the reservation wage $W_R^j(t)$, which is defined as the sum of the expected value of a job, $m^j(t)\xi^j(t)$, and the unemployment benefit, R^j . For the sake of clarity, we drop the time argument below when this causes no confusion.

Intra-temporal allocation of consumption follows from the following optimal rule:

$$\left(\frac{1 - \varphi}{\varphi} \right) \frac{C^T}{C^N} = P^\phi. \quad (15)$$

An appreciation in the relative price of non tradables P increases expenditure on tradables relative to expenditure on non tradables (i.e. C^T/PC^N), only when $\phi > 1$. Applying Shephard's lemma and denoting by $\alpha_C = \frac{(1-\varphi)P^{1-\phi}}{\varphi+(1-\varphi)P^{1-\phi}}$ the share of non traded goods in consumption expenditure yields expenditure in non tradables and tradables, i.e., $PC^N = \alpha_C P_C C$, $C^T = (1 - \alpha_C) P_C C$.

3.2 Firms

Each sector consists of a large number of identical firms which use labor, L^j , as the sole input in a linear technology, $Y^j = A^j L^j$. Firms post job vacancies V^j to hire workers and

²⁵First-order conditions consist of (14a) and (14c) together with $\zeta^j(F^j)^{1/\sigma_L^j} = m^j \xi'^j + R^j \lambda$ and $\xi' = (s^j + \beta) \xi'^j - \left[\lambda W^j - \zeta^j(F^j)^{1/\sigma_L^j} \right]$. Denoting by $\xi^j \equiv \xi'^j / \lambda$, using (14a) and (14c), we get (14b) and (14d).

face a cost per job vacancy κ^j which is assumed to be constant and measured in terms of the traded good. Firms pay the wage W^j decided by the generalized Nash bargaining solution. As producers face a labor cost W^j per employee and a cost per hiring of κ^j , the profit function of the representative firm in sector j is:

$$\pi^j = \Xi^j L^j - W^j L^j - \kappa^j V^j - x^j \cdot \max\{0, -\dot{L}^j\}, \quad (16)$$

where Ξ^j is the marginal revenue of labor; x^j is a firing tax paid to the government when layoffs are higher than hirings, i.e., if $\dot{L}^j < 0$ (see e.g., Heijdra and Ligthart [2002], Veracierto [2008]). The firing tax is introduced to capture the strictness of legal protection against dismissals and is modelled as a tax on reducing employment.²⁶

Denoting by f^j the rate at which a vacancy is matched with unemployed agents, the law of motion for labor is given by:

$$\dot{L}^j = f^j V^j - s^j L^j. \quad (17)$$

Denoting by γ^j the shadow price of employment to the firm, the maximization problem yields the following first-order conditions:

$$\gamma^j + x^j = \frac{\kappa^j}{f^j(\theta^j)}, \quad (18a)$$

$$\dot{\gamma}^j = \gamma^j (r^* + s^j) - (\Xi^j - x^j s^j - W^j). \quad (18b)$$

Eq. (18a) requires the marginal cost of vacancy, κ^j , to be equal to the expected marginal benefit of hiring, $f^j(\gamma^j + x^j)$. Solving (18b) forward and invoking the transversality condition yields:

$$\gamma^j(t) = \int_t^\infty [\Xi^j(\tau) - x^j s^j - W^j(\tau)] e^{(s^j + r^*)(t-\tau)} d\tau. \quad (19)$$

Eq. (19) states that γ^j is equal to the present discounted value of the cash flow earned on an additional worker, consisting of the excess of marginal revenue of labor Ξ^j over the wage W^j and the expected firing cost $x^j s^j$. Following higher productivity A^j , the marginal revenue of labor Ξ^j rises; hence hiring becomes more profitable which induces firms to post job vacancies, but less so in countries with a higher firing cost x^j .

3.3 Matching and Wage Determination

In each sector, there are job-seeking workers U^j and firms with job vacancies V^j which are matched in a random fashion. Assuming a constant returns to scale matching function, the number of labor contracts M^j concluded per job seeker U^j gives the job finding rate m^j which is increasing in the labor market tightness θ^j :

$$m^j = M^j/U^j = X^j (V^j/U^j)^{\alpha_V^j} = X^j (\theta^j)^{\alpha_V^j}, \quad (20)$$

²⁶While employment is lowered, the shrinking establishment is hiring; thus assuming a tax on reducing employment implies that the representative firm simultaneously pays a tax on employment exits and receives a hiring subsidy, the former being higher than the latter amount, i.e., $-x^j \dot{L}^j = x^j s^j L^j - x^j f^j V^j > 0$.

where α_V^j represents the elasticity of vacancies in job matches and X^j corresponds to the matching efficiency. The number of matches M^j per job vacancy gives the worker-finding rate for the firm, f^j , which is decreasing with θ^j :

$$f^j = M^j/V^j = X^j (\theta^j)^{\alpha_V^j - 1}. \quad (21)$$

When a vacancy and a job-seeking worker meet, a rent is created which is equal to $\xi^j + \gamma^j + x^j$, where ξ^j is the value of an additional job, γ^j is the value of an additional worker, and x^j corresponds to the hiring subsidy.²⁷ The division of the rent between the worker and the firm determined by generalized Nash bargaining leads to the product wage W^j defined as a weighted sum of the labor marginal revenue plus the interest income from the hiring subsidy and the reservation wage:

$$W^j = \alpha_W^j (\Xi^j + r^* x^j) + (1 - \alpha_W^j) W_R^j, \quad (22)$$

where α_W^j and $1 - \alpha_W^j$ correspond to the bargaining power of the worker and the firm.

3.4 Government

The final agent in the economy is the government. Unemployment benefits $R^T U^T + R^N U^N$ are covered by lump-sum taxes T and the proceeds from the firing tax $\sum_j x^j \cdot \max\{0, -\dot{L}^j\}$ according to the following balanced budget constraint:²⁸

$$\sum_j x^j \cdot \max\{0, -\dot{L}^j\} + T = \sum_j R^j U^j. \quad (23)$$

3.5 Market Clearing Conditions

We have to impose the market clearing condition for the non traded good:

$$Y^N(t) = C^N(t). \quad (24)$$

Using the definition of the stock of financial wealth $A(t) \equiv B(t) + \sum_j \gamma^j(t) L^j(t)$, differentiating with respect to time, substituting the accumulation equations of labor (12) and financial wealth (13) together with the dynamic equation for the shadow value of an additional worker (18b), using (23) and (24), the current account is:

$$\dot{B}(t) = r^* B(t) + Y^T(t) - C^T(t) - \kappa^T V^T(t) - \kappa^N V^N(t). \quad (25)$$

²⁷As mentioned above, the firing tax is modelled as a tax on reducing employment; because firms experience simultaneously outflow and inflow of workers, this shortcut to encompass the strictness of employment protection implies that establishments pay firing taxes and receive hiring subsidies at the same time, the former being larger than the latter amount.

²⁸In the numerical analysis, we consider government spending for calibration purpose. In this case, eq. (23) can be rewritten as follows: $\sum_j x^j \cdot \max\{0, -\dot{L}^j\} + T = (R^T U^T + R^N U^N) + G^T + P G^N$ where G^T and G^N government spending on tradables and non tradables, respectively.

3.6 Steady-State

We now describe the steady-state of the economy. Due to the lack of empirical estimates at a sectoral level, and to avoid unnecessary complications, we impose $\alpha_V^j = \alpha_V$, $\alpha_W^j = \alpha_W$, $\sigma_L^j = \sigma_L$ from now on.

First, setting $\dot{B} = 0$ into (25), denoting by $v_{NX} \equiv NX/Y^T$ the ratio of net exports to traded output, and using (24) yields the goods market equilibrium:²⁹

$$\frac{Y^T (1 - v_{NX})}{Y^N} = \frac{\varphi}{1 - \varphi} P^\phi, \quad (26)$$

where we have inserted the allocation of aggregate consumption expenditure between traded and non traded goods given by (15). According to (26), following a rise in traded output relative to non traded output, the relative price of non tradables, P , must appreciate to clear the goods market and all the more so as the elasticity of substitution ϕ is smaller.

Second, setting $\dot{\gamma}^j = 0$ into (18b), using (18a) to eliminate γ^j , and inserting W^j given by (22) leads to the vacancy creation equation which states that the marginal benefit of an additional worker to the firm, i.e., $\frac{(1-\alpha_W)}{s^j+r^*} \Psi^j$ (with Ψ^j given by (1)) equalizes the expected costs of recruitment per worker, i.e., κ^j/f^j . Inserting (21) and combining hiring decisions for the traded and non traded sectors give:

$$\frac{\kappa^T (s^T + r^*) X^N}{\kappa^N (s^N + r^*) X^T} \left(\frac{\theta^T}{\theta^N} \right)^{1-\alpha_V} = \frac{\Xi^T + r^* x^T - W_R^T}{\Xi^N + r^* x^N - W_R^N}, \quad (27)$$

where $\Xi^T = A^T$ and $\Xi^N = PA^N$. According to the vacancy creation equation described by (27), higher productivity in tradables relative to non tradables has an expansionary effect on labor demand in the traded sector and thus pushes up θ^T/θ^N as long as $\phi > 1$. Intuitively, higher A^T/A^N appreciates P . If $\phi > 1$, the share of tradables rises which in turn stimulates hirings in the traded sector relative to those in the non traded sector.

Third, setting $\dot{\xi}^j = 0$ into (14d) leads to $\xi^j = \frac{\alpha_W \Psi^j}{s^j+r^*}$. Rewriting the latter equation by inserting the vacancy creation equation for sector j to eliminate Ψ^j gives the expected value of finding a job, i.e., $m^j \xi^j = \frac{\alpha_W}{1-\alpha_W} \kappa^j \theta^j$. Plugging this equation into (14b) leads to the equality between the utility loss from participating in the labor market in sector j , $\frac{\zeta^j (F^j)^{\frac{1}{\sigma_L}}}{\lambda}$, and the marginal benefit from search, $\frac{\alpha_W}{1-\alpha_W} \kappa^j \theta^j + R^j = W_R^j$. Combining the decision of search for the traded and the non traded sector gives:

$$\frac{L^T}{L^N} = \frac{m^T m^N + s^N}{m^N m^T + s^T} \left(\frac{W_R^T \zeta^N}{W_R^N \zeta^T} \right)^{\sigma_L}, \quad (28)$$

where we set $\dot{L}^j = 0$ into (12) to eliminate U^j . According to (28), a rise in θ^T/θ^N has an expansionary effect on hours worked in the traded sector because more unemployed agents

²⁹Denoting by $v_B \equiv \frac{r^* B}{Y^T}$ the ratio of interest receipts to traded output and $v_V^j \equiv \frac{\kappa^j V^j}{Y^T}$ the ratio of the cost of hiring in sector $j = T, N$ to traded output, the zero current account equation implies $v_B - v_V^T - v_V^N = -v_{NX}$. While for simplicity purposes, we refer to v_{NX} as the ratio of net exports to traded output, it also includes hiring expenditure, i.e., $NX \equiv Y^T - C^T = NX + \kappa^T V^T + \kappa^N V^N$ with $NX \equiv Y^T - C^T - \kappa^T V^T - \kappa^N V^N$ corresponding to the 'true' definition of the trade balance.

find a job while workers are also encouraged to increase their participation to the labor force in this sector, and all the more so as σ_L is larger.

The long-term equilibrium comprise three equations (26)-(28) which can be solved for relative employment, L^T/L^N , the ratio of sectoral labor market tightness, θ^T/θ^N , and the relative price, P , as functions of relative productivity, A^T/A^N , and v_{NX} . Inserting these solutions into the Nash bargaining wage (22) and the unemployment rate differential (4) allows us to express the relative wage, $\Omega = W^N/W^T$ and the relative unemployment rate u^T/u^N , in terms of A^T/A^N and v_{NX} . This procedure to solve for the steady-state enables us to break down analytically the effects of a productivity differential between tradables and non tradables into two components as detailed in the next section.³⁰

4 Higher Relative Productivity and Labor Market Frictions

Since the forces which shape the relative wage and relative price responses to an increase in A^T/A^N determine the behavior of the unemployment rate differential between tradables and non tradables, we first explore their adjustment. We thus analytically break down the relative wage and relative price effects in two components to shed some light on the transmission mechanism and investigate the implications of labor market institutions.³¹ Then we extend this analysis to the unemployment rate differential between tradables and non tradables and investigate the transitional adjustment of sectoral unemployment rates by using phase diagrams.

4.1 Inspecting the Transmission Mechanism

Equating demand (26) and supply (27)-(28) of tradables in terms of non tradables, leads to a relationship between the deviation in percentage of the relative price from its initial steady-state and the productivity differential:³²

$$\hat{p} = \frac{(1 + \Theta^T) \hat{a}^T - (1 + \Theta^N) \hat{a}^N}{(\phi + \Theta^N)} + \frac{d \ln(1 - v_{NX})}{(\phi + \Theta^N)}, \quad (29)$$

³⁰When solving the steady-state, changes in the net foreign asset position and thus in net exports as reflected by changes in v_{NX} are assumed to be exogenous. Such a procedure allows us to isolate the effects stemming from changes in the trade balance and hiring expenditure. The ratio v_{NX} can be expressed in terms of sectoral productivities by using the intertemporal solvency condition obtained by linearizing (25) and invoking the intertemporal solvency condition. More details can be found in the Technical Appendix.

³¹It compares the steady-state of the model before and after the productivity shock biased towards the traded sector.

³²Totally differentiating the goods market equilibrium (26) yields: $(\hat{y}^T - \hat{y}^N) = \phi \hat{p} - d \ln(1 - v_{NX})$. Remembering that $\hat{w}_R^j = \chi^j \hat{\theta}^j$ and totally differentiating the vacancy creation equation for sector j gives the deviation in percentage of the sectoral labor market tightness from its initial steady-state, i.e., $\hat{\theta}^j = \frac{\Xi^j \hat{\Xi}^j}{[(1 - \alpha_V) \Psi^j + \chi^j W_R^j]}$. Totally differentiating the decision of search equation for sector j leads to $\hat{l}^j = \sigma_L \hat{\lambda} + [\alpha_V u^j + \sigma_L \chi^j] \hat{\theta}^j$. Substituting the former into the latter, differentiating the production function to eliminate \hat{l}^j , and using the fact that $\chi^j W_R^j = \frac{\alpha_W \Psi^j}{s^j + r^*}$ at the steady-state, one obtains $\hat{y}^j = \hat{a}^j + \Theta^j \hat{\Xi}^j$ where Θ^j is given by (30). The output differential along the labor market equilibrium is thus given by $(\hat{y}^T - \hat{y}^N) = -\Theta^N \hat{p} + (1 + \Theta^T) \hat{a}^T - (1 + \Theta^N) \hat{a}^N$. Combining the goods with the labor market equilibrium leads to (29).

where we set

$$\Theta^j \equiv \frac{\Xi^j (s^j + r^*) [\alpha_V u^j + \sigma_L \chi^j]}{\Psi^j [(1 - \alpha_V) (s^j + r^*) + \alpha_W m^j]}, \quad (30)$$

in order to write expressions in a compact form. The elasticity Θ^j of sectoral employment L^j w.r.t. the marginal revenue of labor Ξ^j is a measure of the degree of labor mobility across sectors which captures both the size of workers' mobility costs and the extent of search frictions. In order to facilitate the discussion, we assume that $\Theta^j \simeq \Theta$.³³ Under this assumption, (29) reduces to:

$$\hat{p} = \frac{(1 + \Theta) (\hat{a}^T - \hat{a}^N)}{(\phi + \Theta)} + \frac{d \ln(1 - v_{NX})}{(\phi + \Theta)}, \quad (31)$$

where $d \ln(1 - v_{NX}) \simeq -dv_{NX}$ by using a first-order Taylor approximation.

Eq. (31) breaks down the relative price response into two components: a labor market frictions effect and a labor accumulation effect. The first term on the RHS of (31) corresponds to the labor market frictions effect. Through this channel, higher productivity gains in tradables relative to non tradables tend to appreciate p . The reason is that a productivity shock biased toward the traded sector raises traded output relative to non traded output so that p must increase to clear the goods market. Importantly, the size of the relative price appreciation is given by the elasticity $\frac{(1+\Theta)}{(\phi+\Theta)}$. When we let σ_L tend toward infinity, workers no longer experience a utility loss when shifting from one sector to another; hence the case of perfect mobility of labor across sectors is obtained as reflected by the term Θ that tends toward infinity; in this configuration, a productivity differential between tradables and non tradables by 1% appreciates p by 1% as well. As long as $\sigma_L < \infty$, workers experience a mobility cost when moving from one sector to another so that the term Θ takes finite values. In this configuration, the relative price of non tradables is jointly determined by technological and demand conditions. Hence, the elasticity ϕ between traded and non traded goods in consumption plays a pivotal role in the determination of the relative price response. If $\phi > 1$ ($\phi < 1$), p appreciates by less (more) than $\hat{a}^T - \hat{a}^N$.

The second term on the RHS of (31) reveals that a productivity differential between tradables and non tradables also impinges on p by affecting the trade balance and hiring expenditure expressed as a share of traded output, as summarized by dv_{NX} . More precisely, through the labor accumulation channel, higher productivity gains in tradables relative to non tradables increase v_{NX} which exerts a negative impact on p by raising the demand for tradables in the long-run. Intuitively, higher productivity, A^j , raises the shadow value of an additional worker γ^j and thus induces firms in both sectors to hire more. Because job vacancies V^j are a jump variable, it overshoots on impact. Since hiring is a costly activity, recruiting expenditures rise substantially. While employment builds up, the open economy finances the accelerated hiring process by running a current account deficit in the

³³For the baseline calibration, while labor market parameters are allowed to vary across sectors Θ^T and Θ^N are very similar if not identical. It is only when the firing costs are important that Θ^T and Θ^N differ substantially.

short-run. For the country to remain solvent, the deterioration in the net foreign asset position must be offset by a steady-state increase in net exports. The combined effect of the improvement in the trade balance and the permanently increased hiring expenditure has an expansionary effect on the demand for tradables which drives down p , regardless of the value of the elasticity of substitution, ϕ . To conclude, as long as the elasticity of labor supply takes finite values (i.e., $\sigma_L < \infty$), we will have to determine numerically if the labor accumulation effect more than offsets the labor market frictions effect when $\phi < 1$ so that $\hat{p} < 1\%$ following a rise in the productivity of tradables relative to non tradables by 1%.

We now explore the long-run response of the relative wage of non tradables to a productivity differential. To do so, we first totally differentiate the vacancy creation equation that we substitute into the Nash bargaining wage (22) expressed in rate of change relative to the steady-state:³⁴

$$\hat{w}^j = \Omega^j \hat{\Xi}^j, \quad \Omega^j \equiv \frac{\Xi^j}{W^j} \frac{\alpha_W [(1 - \alpha_V)(s^j + r^*) + m^j]}{[(1 - \alpha_V)(s^j + r^*) + \alpha_W m^j]} > 0, \quad (32)$$

where $\hat{\Xi}^T = \hat{a}^T$ and $\hat{\Xi}^N = \hat{p} + \hat{a}^N$. Calculating $\hat{\omega} \equiv \hat{w}^N - \hat{w}^T$ by using (32) and substituting (29) yields the deviation in percentage of the relative wage from its initial steady-state:

$$\hat{\omega} = \left\{ \Omega^N \left[\frac{(1 + \Theta^T) \hat{a}^T + (\phi - 1) \hat{a}^N}{(\phi + \Theta^N)} \right] - \Omega^T \hat{a}^T \right\} + \Omega^N \frac{d \ln(1 - v_{NX})}{\phi + \Theta^N}. \quad (33)$$

Assuming $\Theta^j \simeq \Theta$ and $\Omega^j \simeq \Omega$ to facilitate the discussion implies that (33) reduces to:³⁵

$$\hat{\omega} = -\Omega \left[\frac{(\phi - 1)}{\phi + \Theta} (\hat{a}^T - \hat{a}^N) - \frac{d \ln(1 - v_{NX})}{\phi + \Theta} \right]. \quad (34)$$

When assuming perfect mobility of labor across sectors, i.e., if we let σ_L tend toward infinity, we have $\Theta \rightarrow \infty$; hence (34) shows that a productivity differential leaves unaffected ω . Conversely, as long as workers experience a utility loss when shifting (i.e., assuming $\sigma_L < \infty$), higher productivity gains in tradables relative to non tradables impinge on ω through two channels.

When keeping fixed v_{NX} , (34) reduces to $-\Omega \frac{(\phi - 1)}{\phi + \Theta} (\hat{a}^T - \hat{a}^N)$. Hence, through the labor market frictions channel, a productivity differential between tradables and non tradables lowers the relative wage ω only if $\phi > 1$. With an elasticity of substitution ϕ greater than one, the demand for tradables rises more than proportionally. By raising the share of tradables in total expenditure, higher productivity gains in tradables relative to non tradables induce traded firms to hire more which lowers ω . Conversely, with an elasticity ϕ smaller than one, the share of non tradables rises which has an expansionary effect on recruitment in the non traded sector. Hence, in this case, ω increases instead of declining, in contradiction with our empirical findings.

³⁴Totally differentiating (22) gives $\hat{w}^j = \frac{\alpha_W \Xi^j}{W^j} \hat{\Xi}^j + (1 - \alpha_W) \frac{\chi^j W_R^j}{W^j} \hat{\theta}^j$. Inserting in the above equation the vacancy creation equation expressed in percentage deviation from initial steady-state, i.e., $\hat{\theta}^j = \frac{\Xi^j \hat{\Xi}^j}{[(1 - \alpha_V) \Psi^j + \chi^j W_R^j]}$, and using the fact that at the steady-state, $\chi^j W_R^j = m^j \xi^j = \frac{m^j \alpha_W \Psi^j}{s^j + r^*}$, one obtains (32).

³⁵For the baseline scenario of our quantitative analysis, i.e., when calibrating to a typical OECD economy, Ω^T and Ω^N are almost identical.

As captured by the second term on the RHS of (34), a productivity differential between tradables and non tradables also impinges on ω through a labor accumulation channel. More specifically, higher demand for tradables triggered by the improvement in the trade balance encourages traded firms to hire more which exerts a negative impact on the relative wage.

While ω unambiguously declines if the elasticity of substitution is larger than one, when $\phi < 1$, the relative wage response to a productivity differential is ambiguous. In the latter case, higher productivity in tradables relative to non tradables drives down ω through the labor accumulation channel while it increases the relative wage through the labor market frictions channel. We address this ambiguity numerically later.

In our model, the elasticity of labor supply at the extensive margin, σ_L , plays a key role in the determination of the relative wage adjustment. When the labor force participation decision is endogenized, the situations of total immobility ($\sigma_L = 0$) and perfect mobility ($\sigma_L \rightarrow \infty$) of labor emerge as special cases. If we let $\sigma_L = 0$, the situation of total labor immobility is obtained. Because the mobility costs are prohibitive, the labor force is fixed in both sectors. As will be clear later when discussing quantitative results, such a configuration reduces the likelihood that our model trustfully replicates our empirical findings.

Conversely, when we let σ_L tend toward infinity, workers are no longer subject to switching costs; in this configuration, we have $\Theta^j \rightarrow \infty$ so that (29) reduces to $\hat{p} = (\hat{a}^T - \hat{a}^N)$, as in the standard BS model. Inserting the relative price equation into $\hat{\Xi}^N = \hat{p} + \hat{a}^N$, the deviation in percentage of the relative wage from its initial steady-state (33) can be rewritten as $\hat{\omega} = (\Omega^N - \Omega^T) \hat{a}^T$. Such an equality reflects the fact that even if mobility costs are absent, technological change biased toward the traded sector may produce different sectoral wage responses because search parameters vary across sectors. However, the quantitative analysis conducted in section 5 reveals that the elasticity Ω^j of sectoral wages w.r.t. the marginal revenue of labor is almost identical across sectors (as long as firing costs are low), i.e., $\Omega^T \simeq \Omega^N$; hence, if $\sigma_L \rightarrow \infty$, we would have $\hat{\omega} \simeq 0$. Standard search frictions are thus insufficient on their own to produce significant long-run movements in the relative wage.

4.2 Implications of Labor Market Regulation

We now explore the ability of our model to account for our empirical findings established in section 2.5. So far, we have shown that the relative wage of non tradables no longer remains fixed following higher productivity gains in tradables relative to non tradables because workers experience a mobility cost (as captured by $0 < \sigma_L < \infty$) which must be covered by higher wages. While searching for a job is costly because it is time consuming, in a model with search in the labor market, hiring is also a costly activity. By affecting the marginal benefit of hiring, labor market institutions determine the elasticity of labor demand to productivity gains. Because labor market regulation influences the hiring process

and the subsequent adjustment of sectoral output to technology shocks, we also address the implications of labor institutions for the relative price adjustment. Since the transmission mechanism varies according to the type of labor market institution, we differentiate between the firing cost on the one hand, the generosity of the unemployment benefit scheme and the worker bargaining power on the other.

4.2.1 Higher Firing Tax

In our model, the strictness of legal protection against dismissals is captured by a firing tax denoted by x^j paid to the State by the representative firm in the sector which reduces employment. Productivity gains exert two opposite effects on labor L^j . On the one hand, by producing a positive wealth effect, as reflected by a fall in the shadow value of wealth $\bar{\lambda}$, a higher productivity exerts a negative impact on employment by driving down labor supply (see eq. (14b)). On the other hand, by increasing the marginal revenue of labor, a rise in A^j induces firms to recruit more which pushes up employment. Because productivity shocks are biased toward the traded sector, hours worked increase in the traded sector while labor in the non traded sector declines. As non traded establishments are shrinking, firms must pay a firing cost on reducing employment. Thus, according to (19), higher productivity induces non traded firms to post more job vacancies but less so as the firing tax is increased because the surplus from hiring rises by a smaller amount. Since hirings in the non traded sector are relatively less profitable in countries where the firing tax is higher, the labor market tightness θ^N (and thus W^N) increases by a smaller amount.

When $\phi > 1$, higher productivity gains in tradables relative to non tradables increases the surplus of hirings in the traded sector relative to that in non traded sector. Hence, the ratio of labor market tightness (i.e., θ^T/θ^N) rises, and more so as the firing cost paid by non traded firms to the State is higher because hiring in the non traded sector is limited by the firing tax. Consequently, ω declines more, in line with our empirical findings, through a stronger labor market frictions effect. Because non traded firms tend to recruit less in countries where the firing tax is higher, labor and thus output of non tradables tends to increase by a smaller amount so that the relative price appreciates more. However, a higher firing tax also mitigates the decline in ω and the appreciation in p since net exports increase less. Intuitively, as recruiting expenditure are curbed by the firing tax, the productivity differential leads to a smaller current account deficit, thus moderating the necessary trade balance improvement.

In terms of (33), a higher firing tax (paid by non traded firms) lowers substantially the term Ω^N which is the elasticity of the non traded wage to the marginal revenue of labor. The term in braces in (33) which captures the labor market frictions channel is thus higher in absolute terms (or more negative) when $\phi > 1$. Conversely, when $\phi < 1$, the term in braces in (33) becomes positive but smaller as the firing tax x is increased. Regarding the

relative price equation (29), a stricter employment legislation against dismissals lowers Θ^N and thus amplifies the effect of higher productivity in tradables relative to non tradables on p . Moreover, as mentioned above, in countries where the firing tax is higher, net exports increase less which lowers $dv_{NX} > 0$ in the last term of (29) and (33). Thus, the firing tax moderates the labor accumulation effect and thus mitigates the negative impact on p and ω .

4.2.2 Higher Unemployment Benefit Replacement Rate or Worker Bargaining Power

In our framework, the generosity of the unemployment benefit scheme is captured by the level of R^j ; unemployment benefits are assumed to be a fixed proportion ϱ of the wage rate W^j , i.e., $R^j = \varrho W^j$. Additionally, a higher worker bargaining power measured empirically by the bargaining coverage is captured by the parameter α_W .

In contrast to a firing tax, raising ϱ or α_W leads to a larger long-run rise in net exports and thus amplifies the decline in ω and mitigates the appreciation in the relative price through the labor accumulation channel. The reason is as follows. In countries where unemployment benefits are more generous or the worker bargaining power is larger, there are more job-seeking workers and less job vacancies, thus resulting in lower labor market tightness θ^j in both sectors. Consequently, following higher productivity, firms are more willing to recruit additional workers because hiring is more profitable as the probabilities of fulfilling vacancies (f^j) are much higher. Hence, the open economy experiences a larger current account deficit along the transitional path which must be matched in the long-run by a greater improvement in the balance of trade. By amplifying the rise in net exports and thus the demand for tradables, a productivity shock biased toward the traded sector exerts a larger negative impact on ω and p in countries with a higher ϱ or a larger α_W . While a productivity differential lowers further ω and p through higher net exports, increased labor mobility tends to mitigate the impact of the trade balance. More precisely, larger values of ϱ , by reducing the expected cost of hiring (because the probability f^j is higher), or higher values of α_W , by raising the marginal benefit of search, increase the mobility of labor across sectors (captured by Θ^j). Because workers are more willing to search for a job in countries with higher α_W or ϱ , larger values of Θ^j mitigate the negative impact of increased net exports on ω and p .

Since it is found analytically that the three dimensions of labor market regulation exert opposite effects on the elasticity of ω and p to a productivity differential, we conduct a quantitative analysis in section 5.

4.3 Effects on Sectoral Unemployment Rates

We now emphasize the implications of labor market frictions for unemployment effects of higher relative productivity. Importantly, our framework is tractable enough to analyze the

adjustment of sectoral unemployment in the long- and the short-run as well.

We begin with the long-run effect of A^T/A^N on the unemployment rate differential between tradables and non tradables. Setting $\dot{L}^j = 0$ into (12) gives us the standard negative relationship between the unemployment rate, u^j , and labor market tightness, θ^j :

$$u^j = \frac{s^j}{s^j + m^j(\theta^j)}. \quad (35)$$

The labor market steady-state in sector $j = T, N$ is described by a decision of search- and a vacancy creation-schedule (henceforth labelled DSj and VCj), respectively:³⁶

$$L^j = (1 - u^j) \left(\bar{\lambda} W_R^j / \zeta^j \right)^{\sigma_L}, \quad (36a)$$

$$\frac{\kappa^j}{f^j} = \frac{(1 - \alpha_W)}{(s^j + r^*)} \Psi^j, \quad (36b)$$

where W_R^j and Ψ^j are the reservation wage and overall surplus from an additional job in sector j . Eqs. (35) and (36a) determine the DSj -schedule which is downward-sloping in the (u^j, L^j) -space. Intuitively, a rise in θ^j raises the probability of finding a job and thereby the marginal benefit of search which increases L^j and lowers u^j . Eqs. (35) and (36b) determine the VCj -schedule which is vertical in the traded sector (see Figure 2(a)) and upward-sloping in the non traded sector (see Figure 2(b)).³⁷ Intuitively, a rise in L^N increases non traded output and thereby exerts a downward pressure on the relative price; because the marginal benefit of hiring falls, θ^N declines, and thus u^N increases. Since the terms of trade are fixed, a rise in L^T leaves u^T unaffected along the VCT -schedule.

The initial steady-state is at point H_0^j in the first row of Figure 2 while the final steady-state is at H_1^j . A rise in relative productivity produces a positive wealth effect which lowers labor supply and thus shifts the DSj -schedule downward in sector j . At the same time, by raising the surplus from hiring, higher labor productivity shifts the VCj -schedule to the left. As firms recruit more, the labor market tightness θ^j increases which lowers the unemployment rate in both sectors. Under certain conditions we detail below, the shift of the VCj -schedule to the left is larger in the traded sector which results in a greater decline in u^T than in u^N .

Steady-State Effects. Setting $\Sigma^j = \frac{\Xi^j}{(1 - \alpha_V)\Psi^j + \chi^j W_R^j}$, the steady-state change in the labor market tightness is $\hat{\theta}^j = \Sigma^j \hat{\Xi}^j$. Using the latter result, totally differentiating (35) and using (31), subtracting du^N from du^T , the change in the unemployment rate differential between tradables and non tradables in percentage point reads as:

$$du^T - du^N = -\alpha_V u (1 - u) \Sigma \left[\left(\frac{\phi - 1}{\phi + \Theta} \right) (\hat{a}^T - \hat{a}^N) - \frac{d \ln(1 - v_{NX})}{(\phi + \Theta)} \right], \quad (37)$$

³⁶Setting $\dot{L}^j = 0$ into (12) and $\dot{\xi}^j = 0$ into (14b) leads to the DSj -schedule in sector j . Setting $\dot{\gamma}^j = 0$ into (18b), and inserting W^j given by (22) leads to the VCj -schedule in sector j .

³⁷Totally differentiating (35) and (36a) leads to DS^j -schedule in the (u^j, L^j) -space, i.e., $\frac{d \ln L^j}{d \ln u^j} \Big|_{L^j=0} = -\frac{[\alpha_V u^j + \sigma_L \chi^j]}{\alpha_V (1 - u^j)} < 0$. Totally differentiating (35) and (36b) leads to the VC^j -schedule in the (u^j, L^j) -space, i.e., $\frac{d \ln L^j}{d \ln u^j} \Big|_{\hat{\theta}^j=0} = -\frac{(1 - \alpha_V)\Psi^j + \chi^j W_R^j}{\alpha_V (1 - u^j)\Xi_{L^j}^j} > 0$ where $\Xi_{L^j}^j = \partial \Xi^j / \partial L^j \leq 0$.

where we assume that search parameters are such that $\Theta^j \simeq \Theta$, $u^j \simeq u$, $\Sigma^j \simeq \Sigma$ to facilitate the discussion. When we let $\sigma_L \rightarrow \infty$, the term Θ tends toward infinity as well so that the unemployment rate differential remains unchanged.³⁸ Intuitively, when job search costs are absent, p appreciates by the same amount as $\hat{a}^T - \hat{a}^N$ so that the marginal revenue of labor and thus labor market tightness rises evenly across sectors.

As captured by the first term on the RHS of (37), if $\phi < 1$, higher A^T/A^N lowers u^T less than u^N , i.e., $du^T - du^N > 0$, through the labor market frictions channel. The second term on the RHS of (37) reveals that the long-run improvement in the balance of trade drives down the unemployment rate differential, i.e., $du^T - du^N < 0$, through the labor accumulation channel. Whilst numerical results discussed in the next section show that the latter channel predominates, labor market regulation should amplify the decline in the relative unemployment rate of tradables. Intuitively, in countries where the worker bargaining power or the replacement rate is higher, net exports and thus the demand for tradables increases more. In addition, as employment protection legislation becomes more stringent, θ^N increases less through the labor market frictions channel.

Short-Run Effects. The dynamic effects of a productivity differential on sectoral unemployment rates are depicted in Figure 2(a) and 2(b). The stable branch labelled $X^j X^j$ is downward-sloping and flatter than the DS^j -schedule.³⁹ Along the stable transitional path, employment and unemployment rate vary in opposite direction. Because labor is a state variable, L^j remains unchanged on impact. On the contrary, U^j , is a control variable which falls sharply on impact since the positive wealth effect encourages agents to reduce time devoted to job search. Thus sectoral unemployment rates decrease at time $t = 0$. Graphically, the economy jumps initially at $H^{j'}$.

As can be seen in the first row of Figure 2, u^N overshoots its new steady-state level and thus should decline more on impact than u^T . Intuitively, while the positive wealth effect lowers U^j in both sectors, higher A^T/A^N mitigates the decline in u^T by exerting a positive impact on the marginal benefit of search. The adjustment in L^j along the transitional path reverses this outcome though since the technology shock is biased toward the traded sector. As employment builds up in the traded sector, thus lowering u^T along the stable path, the gradual decrease in L^N raises u^N . In the long-run, higher A^T/A^N lowers the unemployment rate differential, i.e., $du^T - du^N < 0$, as long as the labor accumulation channel more than offsets the labor market frictions channel.

< [Please insert Figure 2 about here](#) >

³⁸When we let search parameters vary across sectors and σ_L tend toward infinity, the unemployment rate differential reduces to:

$$\lim_{\sigma_L \rightarrow \infty} (du^T - du^N) = -\alpha_V \left[u^T (1 - u^T) \Sigma^T - u^N (1 - u^N) \Sigma^N \right] \hat{a}^T,$$

where we used the fact that $\lim_{\sigma_L \rightarrow \infty} \hat{p} = \hat{a}^T - \hat{a}^N$. The term in brackets on the RHS of the above equation is merely positive for the baseline calibration.

³⁹The formal proofs can be found in a Technical Appendix.

Implications of labor market regulation for impact effects. Labor market regulation amplifies the rise in $u^T(0) - u^N(0)$ on impact. In economies where ϱ or α_W is higher, u^j declines more in both sectors because the wealth effect is greater. At the same time, the greater trade balance improvement further biases firms' hirings toward the traded sector. Because the marginal benefit of search in the traded sector increases more, U^N falls by a larger amount relative to U^T on impact. Graphically, the VCN -schedule shifts less as a result of a smaller appreciation in p in the long-run so that the stable path $X^N X^N$ is lower in Figure 2(b). As legal protection against dismissals becomes stricter, non traded establishments post less job vacancies and thus agents devote less time to searching for a job in the non traded sector. Since U^N decreases more on impact, the fall in u^N is larger on impact.

5 Quantitative Analysis

In this section, we analyze the effects of a labor productivity differential between tradables and non tradables quantitatively. For this purpose we solve the model numerically.⁴⁰ Therefore, first we discuss parameter values before turning to the quantitative analysis.

5.1 Calibration

To calibrate our model, we estimated a set of parameters so that the initial steady state is consistent with the key empirical properties of a representative OECD economy. While at the end of the section we move a step further and calibrate the model for each economy, we first have to evaluate the ability of the two-sector open economy model with labor market frictions to accommodate our evidence. Our sample covers the eighteen OECD economies in our dataset. Since we calibrate a two-sector model with labor market frictions, we pay particular attention to match the labor market differences between the two sectors. To do so, we carefully estimate a set of sectoral labor market parameters shown in Table 6.⁴¹ Because we consider an open economy setup with traded and non traded goods, we calculate the non-tradable content of employment, consumption, and government spending, and the productivity in tradables in terms of non tradables, for all countries in our sample, as summarized in Table 5. Our reference period for the calibration of the non tradable share given in Table 5 is running from 1990 to 2007 while labor market parameters have been computed over various periods due to data availability. To capture the key properties a typical OECD economy which is chosen as the baseline scenario, we take unweighed average values shown in the last line of Tables 5 and 6. Some of the values of parameters can be taken directly from the data, but others like κ^T , κ^N , X^T , X^N , ζ^N , φ , together with initial

⁴⁰Technically, the assumption $\beta = r^*$ requires the joint determination of the transition and the steady state.

⁴¹To calibrate the labor market for the traded and the non traded sector, we need to estimate the job finding and the job destruction rate for each sector. To do so, we apply the methodology developed by Shimer [2012].

conditions (B_0, L_0^T, L_0^N) , need to be endogenously calibrated to fit a set of labor market and non tradable content features.⁴² We choose the model period to be one month and therefore set the world interest rate, r^* , which is equal to the subjective time discount rate, β , to 0.4%.

We start with the values of the labor market parameters which are chosen so as to match a typical OECD economy. We set the matching efficiency in the traded (non traded) sector X^T (X^N) to 0.307 (0.262) to target a monthly job finding rate m^T (m^N) of 17.4% (17.0%). In accordance with estimates shown in the last line of column 6 (column 8) of Table 6, the job destruction rate s^T (s^N) in the traded (non traded) sector is set to 1.48% (1.54%), which together with the job finding rate m^T (m^N) leads to an unemployment rate u^T (u^N) of 7.9% (8.3%). We obtain an overall unemployment rate u of 8.1%. To target the labor market tightness in the traded sector, $\theta^T = 0.24$, and in the non traded sector, $\theta^N = 0.34$, displayed in the last line of columns 10 and 11 of Table 6, we set the recruiting cost κ^T and κ^N to 1.482 and 0.575, respectively.⁴³

Unemployment benefit replacement rates and the firing cost shown in the latter two columns of Table 6 correspond to averages over 1980-2007 (except Korea: 2001-2007) and 1980-2005, respectively. The unemployment benefits replacement rate, ρ , has been set to 52.4%. To calibrate the firing cost, we take data from FRDB-IMF Labor Institutions Database [2010]; we add the advance notice and the severance payment which are averages after 4 and 20 years of employment. Since the advance notice and the severance payment are both expressed in monthly salary equivalents, we have $x^j = \tau W^j$ with $\tau \geq 0$. For the baseline calibration, we set the firing tax τ to 4.2.⁴⁴

Because the features of labor markets vary substantially across OECD economies, we also analyze two different calibrations of the model, one aimed at capturing the U.S. labor market, the other aimed at capturing Europe with its more 'rigid' labor market. To calibrate a typical European labor market, we take the EU-12 unweighed average.⁴⁵

Using U.S. data, Barnichon [2012] reports an elasticity of the matching function with respect to unemployed workers of about 0.6, an estimate which lies in the middle of the plausible range reported by Petrongolo and Pissarides [2001]. Hence, we set $1 - \alpha_V$ to 0.6. As it is common in the literature, we impose the Hosios condition, and set the worker

⁴²As detailed in a Technical Appendix, the steady-state can be reduced to seven equations which jointly determine θ^T , θ^N , m^T , m^N , L^T/L^N (and thus L^N/L), P (and thus α_C), B (and thus v_{NX}). Among the 20 parameters that the model contains, 14 have empirical counterparts while the remaining 6 parameters, i.e., κ^T , κ^N , X^T , X^N , ζ^N , φ , together with initial conditions (B_0, L_0^T, L_0^N) must be set in order to match θ^T , θ^N , m^T , m^N , L^N/L , α_C , v_{NX} .

⁴³The share of recruiting costs in GDP is 2.3%.

⁴⁴We model firing costs as a tax that firms have to pay to the State when their employment levels decline, i.e., if $\dot{L}^j < 0$. As mentioned previously, because traded employment monotonically increases while the non traded sector reduces continuously employment following a productivity differential, only the non traded sector is subject to the firing tax.

⁴⁵For sectoral unemployment rates, and monthly job finding and job destruction rates, we take the EU-10 unweighed average due to data availability. See section B.3 that provides the list of countries for EU-12 and EU-10.

bargaining power α_W to 0.6 in the baseline scenario.

Next, we turn to the elasticity of labor supply at the extensive margin which is assumed to be symmetric across sectors. We choose σ_L to be 0.6 in our baseline setting but conduct a sensitivity analysis with respect to this parameter.⁴⁶ Furthermore, in order to target a non tradable content of labor of 66% which corresponds to the 18 OECD countries' unweighted average shown in the last line of Table 5, we normalize ζ^T to 1 and choose a value for ζ^N that parametrizes the disutility from working and searching for a job in the non traded sector, of 0.18 (see eq. (11)).

< Please insert Table 5 and Table 6 about here >

We now turn to the calibration of consumption-side parameters. Building on our panel data estimations, we set the elasticity of substitution to 1 in the baseline calibration.⁴⁷ But we conduct a sensitivity analysis by considering alternatively a value of ϕ smaller or larger than one (i.e., ϕ is set to 0.6 and 1.5, respectively).⁴⁸ The weight of consumption in non tradables $1 - \varphi$ is set to 0.42 to target a non-tradable content in total consumption expenditure (i.e., α_C) of 42%, in line with the average of our estimates shown in the last line of Table 5. The intertemporal elasticity of substitution for consumption σ_C is set to 1.

For calibration purposes, we introduce government spending on traded and non traded goods in the setup. We set G^N and G^T so as to yield a non-tradable share of government spending of 90%, and government spending as a share of GDP of 20%. We assume that, in the initial steady-state, net exports are nil and thus choose initial conditions (B_0, L_0^T, L_0^N) in order to target $v_{NX} = 0$.

We consider a permanent increase in the productivity index A^j of both sectors biased towards the traded sector so that the labor productivity differential between tradables and non tradables, i.e., $\hat{a}^T - \hat{a}^N$, is 1%. While in our baseline calibration we set $\phi = 1$, $\sigma_L = 0.6$, $\alpha_W = 0.6$, $\varrho = 0.524$, $\tau = 4.2$, we conduct a sensitivity analysis with respect to these five parameters by setting alternatively: ϕ to 0.6 and 1.5, σ_L to 0, 0.2 and 1, α_W to 0.9, ϱ to 0.782, and τ to 13.⁴⁹ Finally, in the latter two columns of Table 7, we compare the results for the US economy with those obtained for a typical European economy (EU-12).

⁴⁶Using data from the Panel Study of Income Dynamics, Fiorito and Zanella [2012] find that aggregate time-series results deliver an extensive margin elasticity in the range 0.8-1.4, which is substantially larger than the corresponding estimate (0.2-0.3) reported by Chetty, Friedman, Manoli, and Weber [2011]. A value of 0.6 is halfway between these two sets of findings.

⁴⁷In Appendix B.2, we describe the empirical strategy to estimate ϕ . In particular, we derive a testable equation by combining market clearing conditions for tradables and non tradables and the demand for tradables in terms of non tradables. Details of the derivation of the equation we explore empirically can be found in the Technical Appendix of a longer version of the paper. Excluding estimates of ϕ for Italy which are negative (see Table 9), column 1 of Table 8 reports consistent estimates for the elasticity of substitution ϕ between traded and non traded goods which average to a value close to 1.

⁴⁸These values for ϕ of 0.6 and 1.5 correspond roughly to the averages of estimates of ϕ for countries with $\phi < 1$ and $\phi > 1$, respectively.

⁴⁹When conducting the sensitivity analysis, we raise ϱ from 52.4% to 78.2% and τ from 4.2 to 13, which correspond to the highest value in our sample of countries for the replacement rate and the firing cost, respectively.

5.2 Results

We now assess the ability of the model to account for our empirical findings according to which a productivity differential (by 1%) lowers the relative wage (by 0.22%), appreciates the relative price (by 0.64%), and lowers the unemployment rate of tradables relative to that of non tradables (by 0.034 ppt). We also investigate the implications of the three dimensions of labor market regulation for the effects of higher A^T/A^N .

No mobility costs. The responses of ω and p computed numerically are summarized in Table 7. Since the response of ω is ambiguous when $\phi < 1$, it is convenient to first discuss the numerical results in this configuration. Panels D and E of Table 7 report the long-run changes for ω and p expressed as a percentage. The numbers reported in the first line of each panel give the (overall) responses of these variables to a productivity differential $\hat{a}^T - \hat{a}^N$ of 1%. Column 1 of Table 7 shows that when abstracting from labor market frictions, i.e., setting $\kappa^j = 0$ and $\sigma_L \rightarrow \infty$, the model cannot account for our empirical evidence.

With mobility costs. Conversely, numerical results summarized in column 2 show that when calibrating to a typical OECD economy, a model with labor market frictions can produce a decline in ω and a less than proportional increase in p as found in the data. To shed light on the transmission mechanism of higher productivity in tradables relative to non tradables in a model with labor market frictions, we numerically break down the responses into two components: a labor market frictions channel stemming from changes in the share of tradables and a labor accumulation channel triggered by the accelerated hiring process which increases the demand for tradables in the long-run.

As shown in the second line of panels D and E, a rise by 1% in the productivity of tradables relative to non tradables raises ω by 0.29% and appreciates p by 1.33% through the labor market frictions effect. Intuitively, when $\phi < 1$, a productivity shock biased toward the traded sector raises the share of non tradables into expenditure and thus encourages non traded firms to recruit relatively more than traded firms. To attract workers who experience mobility costs when shifting from one sector to another, w^N must rise relative to w^T . As shown in the third line of panels D and E, the labor accumulation effect counteracts the labor market frictions effect. More specifically, higher A^T/A^N also raises net exports which has an expansionary effect on hirings in the traded sector, thus driving down ω by 0.45%. Higher demand for tradables also depreciates p by 0.47%. Importantly, the labor accumulation effect more than offsets the labor market frictions effect so that ω declines by 0.16% and p appreciates by 0.85%, as summarized in the first line of panels D and E.

Our model with search in the labor market and an endogenous sectoral labor force participation sheds light on two sets of factors influencing the mobility of labor across sectors and thus the responses of ω and p to a productivity differential: the workers' mobility cost reflected by a utility loss when increasing the search intensity for a job in one sector (as

captured by σ_L) and labor market institutions (captured by α_W , ϱ , τ) determining the elasticity of hiring to labor productivity.

Role of labor supply at the extensive margin. As we move from column 3 to column 5, the elasticity of labor supply at the extensive margin σ_L is raised from zero to 1. Column 3 of panels D and E of Table 7 shows numerical results if labor is totally immobile across sectors as captured by setting $\sigma_L = 0$. In this configuration, the labor force is fixed in both sectors because the mobility cost is prohibitive. Since the decision of search is inelastic to the sectoral wage, ω falls by 0.48% instead of 0.16% in the baseline scenario. Hence, such a polar case tends to substantially overstate the decline in ω and thus confirms the pivotal role of an endogenous labor force participation decision. As shown, in columns 4 and 5 of panels D and E of Table 7, raising σ_L from 0.2 to 1 lowers the utility loss induced by the shift from one sector to another which in turn moderates the decline in ω and amplifies the appreciation in p .

Implications of higher unemployment benefits and worker bargaining power. Scenarios summarized in columns 6 and 7 of Table 7 show that, in line with our evidence, raising the worker bargaining power α_W or the unemployment benefit replacement rate ϱ amplifies the decline in ω from 0.16% to 0.21% and 0.25%, respectively. In accordance with our model's predictions, in countries with a higher α_W or ϱ , higher A^T/A^N lowers more ω through the labor accumulation effect, as shown in the third line of panel D. The stronger labor accumulation effect also moderates the appreciation in p from 0.85% to 0.81% and 0.76%, respectively, as shown in the first line of panel E, because the demand for tradables increases more than in the baseline scenario. The second line of panel D also reveals that ω rises less than in the baseline scenario through the labor market frictions channel because the mobility of labor across sectors rises.

Implications of higher firing costs. Column 8 of Table 7 gives results when the firing cost, τ , is about three times larger than in the baseline scenario. In accordance with our empirical findings, raising τ drives down further ω from -0.16% to -0.19%. As shown in the third line of panel D, the labor accumulation channel is merely affected by τ . On the contrary, the second line of panel D reveals that ω increases by a smaller amount because the firing cost curbs the expansionary effect of higher productivity gains on hiring by non traded firms and thus moderates the rise in w^N relative to w^T from 0.29% to 0.25%. Moreover, as shown in the first line of panel E, countries with stringent legal protection against dismissals also experience a larger appreciation in p , in line with our empirical findings, because traded output increases more relative to non traded output.

EU-12 vs. USA. The latter two columns of Table 7 compare the responses of ω and p between a typical European country and the US. Because the legal protection against dismissals is stricter while unemployment benefits are higher, a typical European economy experiences a smaller increase in w^N through the labor market frictions channel and a

larger increase in w^T through the labor accumulation channel. As a result, ω falls by 0.20% in EU-12 and declines by only 0.09% in the US. While a higher τ tends to amplify the appreciation in p , a larger ρ tends to moderate it. The first line of panel D shows that the latter effect dominates so that a productivity differential raises p more in the US (0.90%) than in a European economy (0.82%).

Implications of $\phi = 1$. In panels A and B of Table 7, we consider the scenario $\phi = 1$. Keeping fixed net exports, a productivity differential between tradables and non tradables by 1% would have no effect on ω while p would appreciate by 1% if labor market parameters were identical because the share of tradables in total expenditure remains unchanged. As shown in the second line of panel A, ω falls very slightly because the elasticity of hiring in the traded sector is merely higher than that in the non traded sector. The third line of panel A and B reveals that higher A^T/A^N produces a decline in ω and a rise in p close to our estimates due to the improvement in the balance of trade.

Unemployment rate differential between tradables and non tradables. We now explore the effects of a rise in A^T/A^N on the unemployment rate differential between tradables and non tradables shown in panel C of Table 7. Since the transmission mechanism is identical to that described above for p and ω , we focus on the situation of $\phi = 1$. This case is particularly interesting for the study of $du^T - du^N$ since the second line of panel C gives the change in the relative unemployment rate that would prevail if labor mobility costs were absent.⁵⁰ Through the labor market frictions channel, a productivity differential merely influences the relative unemployment rate of tradables. On the contrary, as displayed in the third line of panel C, the unemployment rate differential falls as a result of higher demand for tradables. Intuitively, when workers incur costs of switching sectors, p appreciates by a smaller amount than $\hat{a}^T - \hat{a}^N$ so that the labor market tightness in the traded sector increases more which produces $du^T - du^N < 0$ in line with our empirical findings. Whereas at first sight, the magnitude appears to be small, changes in sectoral unemployment rates are substantial as the aggregate unemployment rate declines by 0.11 percentage point.

Implications of labor market regulation for the unemployment rate differential. Contrasting the figure in column 2 with those in columns 6,7,8, numerical results reveal that the three dimensions of labor market regulation amplifies the decline in the relative unemployment rate of tradables in line with our evidence. While such an amplification operates through higher demand for tradables when α_W or ρ is raised, increasing the firing cost curbs non traded firms' hiring and thus mitigates the rise in $u^T - u^N$ through the labor market frictions channel.

⁵⁰A unitary elasticity of substitution between tradables and non tradables implies that the share of non tradables remains fixed and thus neutralizes the labor market frictions channel. In this case, the figures in the second line of panel C shows the change in the relative unemployment rate due to differences in standard search frictions between the traded and the non traded labor market, i.e., the change in $u^T - u^N$ that would prevail if labor mobility costs were shut off.

Implications of $\phi > 1$. We briefly discuss the scenario $\phi > 1$. Panels F and G of Table 7 report the long-run responses of ω and p . Because the labor accumulation channel reinforces the labor market frictions channel, the first line of panel F reveals that the model tends to overstate the decline in ω when $\phi > 1$. As shown in the first line of panel G, the model also tends to understate the rise in p because the relative price appreciates less than proportionately through the labor market frictions effect while the rise in net exports depreciates p .

< [Please insert Table 7 about here](#) >

5.3 Model Performance

We now move a step further and compare the predicted values with estimates for each country and the whole sample and thus restrict our attention to relative wage and relative price effects since unemployment differential effects cannot be estimated empirically by country due to data limitation (see Appendix B.3). We use the same baseline calibration for each economy, except for the elasticity of substitution ϕ between traded and non traded goods, and labor market parameters which are allowed to vary across countries. More specifically, ϕ is set in accordance with its estimates shown in the first column of Table 8.⁵¹ The parameters which capture the degree of labor market regulation such as the firing cost, τ , and the replacement rate, ϱ , are set to their values shown in the latter two columns of Table 6. The matching efficiency X^j in sector $j = T, N$ is set to target the job finding rate m^j displayed in columns 5 and 7 of Table 6. The job destruction rate in sector j , s^j , is set in accordance with its value reported in columns 6 and 8 of Table 6. The costs per job vacancy κ^T and κ^N are chosen to target the aggregate labor market tightness θ shown in column 13 and the ratio of sectoral labor market tightness θ^T/θ^N obtained by dividing column 10 by column 11.⁵²

Before discussing the performance of the model, we relate our analytical results to the elasticity of p and ω with respect to the productivity differential, i.e., γ and β (see eqs. (7a)-(7b)), which are estimated empirically. When search frictions are similar across sectors, the long-run responses of p and ω reduce to (31) and (34), respectively. In this configuration, there exists a direct mapping between analytical expressions of $\frac{\hat{p}}{\hat{a}^T - \hat{a}^N}$ and $\frac{\hat{\omega}}{\hat{a}^T - \hat{a}^N}$, and empirical estimates of γ and β , respectively. In contrast, when search frictions vary across sectors, we have to correct for the inherent discrepancy between theoretical and empirical values for γ and β . This discrepancy originates from sector-varying Θ^j and Ω^j which makes

⁵¹We also choose the weight of consumption in non tradables $1 - \varphi$ to target a non-tradable content in total consumption expenditure (i.e., α_C) for each country in line with our estimates shown in column 2 of Table 5.

⁵²Ideally, the recruiting cost κ^j would be set in order to target θ^j ; however, the series for job vacancies by economic activity are available for a maximum of seven years and for a limited number of countries. On the contrary, the OECD provides data for job openings (for the whole economy) over the period 1980-2007 allowing us to calculate the labor market tightness, i.e., $\theta = V/U$, for several countries that we target along with the ratio θ^T/θ^N by choosing κ^T and κ^N .

the theoretical elasticity of p (resp. ω) w.r.t. $\hat{a}^T - \hat{a}^N$ different. To map the deviation in percentage of p and ω from their initial steady-state into elasticities estimated empirically, we need to adjust numerically computed values with a term that captures the extent to which search frictions vary across sectors. Once the discrepancy is accounted for, we are able to relate γ and β estimated empirically to their analytical counterpart which we denote by γ^{predict} and β^{predict} , respectively:⁵³

$$\gamma^{\text{predict}} = \left(\frac{1 + \Theta^T}{\phi + \Theta^N} \right) + \frac{1}{\phi + \Theta^N} \frac{d \ln(1 - v_{NX})}{\hat{a}^T - \hat{a}^N}, \quad (38a)$$

$$\beta^{\text{predict}} = - \left[\Omega^T - \Omega^N \left(\frac{1 + \Theta^T}{\phi + \Theta^N} \right) \right] + \frac{\Omega^N}{\phi + \Theta^N} \frac{d \ln(1 - v_{NX})}{\hat{a}^T - \hat{a}^N}, \quad (38b)$$

where the second term on the RHS of (38a) and (38b) captures the negative impact on p and ω of the long-run adjustment in net exports caused by rise in A^T/A^N

Results are shown in Table 8. Columns 2 and 5 of Table 8 give the predicted responses of $\hat{\omega}$ and \hat{p} to a rise in the productivity of tradables relative to non tradables by 1%. Columns 3 and 6 report FMOLS estimates of $\hat{\omega}$ and \hat{p} for each country, EU-12 and the whole sample.⁵⁴ Columns 4 and 7 give the difference between the actual and the predicted values. As can be seen in the last line, the correlation coefficient between simulated and estimated values for the relative wage response is high which indicates that the model generates a cross-country pattern in the relative wage responses which is similar to that in the data. More specifically, column 4 reveals that our model's predictions for $\hat{\omega}$ are relatively close to the evidence for almost half of the countries in our sample, including France, the UK, Ireland, Italy, Japan, the Netherlands, Spain and the United States, and to a lesser extent Germany, Austria and EU-12. The model predicts fairly well the relative price response for nine countries of our sample, including Austria, Belgium, Germany, Finland, Italy, Japan, the Netherlands, Spain, and the UK. The prediction error is also moderate in Denmark and France. However, the correlation coefficient in the last line of the table indicates that the ability of the model to account for the cross-country pattern in the relative price responses is less than that in the relative wage responses. It is worthwhile mentioning that, whether we focus on $\hat{\omega}$ or \hat{p} , the prediction error is large for Australia, Canada, and Norway which are important natural resources exporters. Hence, for these three economies, we believe that our assumption of given terms of trade is too strong.

When calibrating to the whole sample, the model predicts remarkably well the relative wage response; we find numerically a decline in ω of 0.218% while in the data, ω falls by 0.223%. When we turn to the relative price, the prediction error increases substantially as our model produces an appreciation of 0.778% while we find empirically a rise of 0.636%.

⁵³The correction term for p and ω is $\left(\frac{1 + \Theta^T}{\phi + \Theta^N} \right) \left[1 - \left(\frac{1 + \Theta^N}{1 + \Theta^T} \right) \right] \hat{a}^N$ and $-\left\{ \left[\Omega^T - \Omega^N \left(\frac{1 + \Theta^T}{\phi + \Theta^N} \right) \right] - \left[\Omega^N - \Omega^N \left(\frac{1 + \Theta^N}{\phi + \Theta^N} \right) \right] \right\} \hat{a}^N$, respectively. It is worth mentioning that the magnitude of the bias originating from sector-varying search frictions is quantitatively low.

⁵⁴We reach similar conclusions when using DOLS estimates.

We now investigate whether the long-run response in ω is more pronounced and p appreciates less in countries where labor markets are more regulated, in line with our empirical findings documented in subsection 2.5. In Figure 3, we plot the simulated responses of the relative wage on the vertical axis against the employment protection legislation index adjusted with the share of permanent workers in the economy in Figure 3(a). Figure 3(b) plots simulated responses of the relative wage against an indicator of labor market regulation which encompasses two dimensions, namely the generosity of the unemployment benefit scheme and the extent of the worker bargaining power.⁵⁵ Despite the wide dispersion in the relative wage responses that our model generates, the trend line in Figure 3(a) reveals that the relative wage falls more in countries where legal protection against dismissals is stricter. In Figure 3(b) countries where unemployment benefits are more generous or the worker bargaining power is higher also experience a larger decline in the relative wage. In sum, while productivity gains biased toward the traded sector drive down non traded wages relative to traded wages as the result of job search costs experienced by workers, international differences in hiring costs and thus in the degree of labor market regulation can account for the dispersion in the relative wage responses across countries.

Figure 3(c) plots the simulated responses for the relative price against our measure of labor market regulation which encompasses the extent of the worker bargaining power, the generosity of the unemployment benefit scheme and the strictness of legal protection against dismissals. While both empirical and numerical results show that higher firing costs put upward pressure on the relative price, the trend line in Figure 3(c) indicates that more generous unemployment benefits exert a stronger influence. More specifically, in line with the evidence documented in section 2.5, we find quantitatively that the relative price of non tradables tends to appreciate less in countries with more regulated labor markets.

< [Please insert Table 8 and Figure 3 about here](#) >

5.4 Long- and Short-Run Adjustment of Sectoral Unemployment Rates

An additional major implication of our two-sector model with search frictions is that higher relative productivity leads to a decline in the unemployment rate differential in the long-run as long as the effect of increased demand for tradables is larger than the impact of changes in the share of tradables when $\phi < 1$. Column 8 of Table 8 reports the numerical counterpart of σ which corresponds to the estimated effect of higher relative productivity on the unemployment rate differential adjusted with the bias originating from sector-varying search frictions, i.e.,

$$\sigma^{\text{predict}} = -\alpha_V \Delta^T + \alpha_V u^N (1 - u^N) \frac{\Sigma^N}{\phi + \Theta^N} \frac{d \ln(1 - v_{NX})}{\hat{a}^T - \hat{a}^N}, \quad (39)$$

⁵⁵The labor market regulation index in Figure 3(b) is obtained by using a principal component analysis over the period 1980-2007 which corresponds to the reference period for the calibration of labor market institutions variables.

where $\Delta^T = \left[u^T (1 - u^T) \Sigma^T - u^N (1 - u^N) \Sigma^N \left(\frac{1 + \Theta^T}{\phi + \Theta^N} \right) \right]$. As shown in column 8 of Table 8, the unemployment rate differential falls by 0.011 ppt for an average OECD economy. Column 9 of Table 8 shows the adjustment of the unemployment rate differential that would prevail if labor mobility costs were absent, i.e., if $\sigma_L \rightarrow \infty$. In this situation, the unemployment rate differential increases in a representative OECD economy along with most of the countries in our sample as its response is only driven by differences in standard search frictions between the traded and non traded labor markets.

While the baseline model (for an average OECD economy) tends to understate the magnitude of the decrease in u^T relative to u^N we estimate empirically (see the first row of Table 3), its decline remains substantial though in Belgium, Denmark, France, Germany, Spain where $du^T - du^N$ varies from -0.061 to -0.022 ppt. In this regard, Figure 3(d) reveals that the long-run adjustment of the unemployment rate differential to a rise in A^T/A^N is quite distinct between countries with low and high labor market regulation. In line with our evidence, u^T falls more than u^N in economies with higher labor market regulation.

While so far we have investigated the long-run effects, Figure 2(c) plots the dynamics for sectoral unemployment rates and contrasts the results for a representative OECD economy (shown in solid lines) with those obtained for an economy with more regulated labor markets (shown in dashed lines).⁵⁶ Focusing first on a representative OECD economy, the first conclusion that emerges is that the adjustment is rapid, the sectoral unemployment rates reaching their steady-state values after 3 years approximately. Secondly, whilst in the long-run sectoral unemployment rates decline by about 0.12 ppt with $du^T < du^N < 0$, the fall in job search in the non traded sector is such that u^N decreases by 0.24 ppt on impact, thus reversing $du^T - du^N$ in the short-run. Thirdly, labor market regulation slows down the transitional adjustment toward the steady-state because the probability of finding a job is much lower in countries where ϱ and/or τ is higher. Fourthly, as can be seen in dashed lines in Figure 2(c), the change in the unemployment rate differential is amplified both in the short- and the long-run. Because labor market regulation further biases the positive impact of the technology shock on traded firms' hiring, less agents search for a job in the non traded sector on impact while along the transitional path, recruitment by traded firms lowers u^T .

6 Conclusion

While the literature exploring the implications of higher productivity in tradables relative to non tradables commonly assumes frictionless labor markets, our empirical results show that the non traded wage tends to decline relative to the traded wage. Because the non traded wage increases at a lower speed than the traded wage, it is found empirically that

⁵⁶When we consider an OECD economy with high labor market regulation, we set ϱ to 78.2% and the firing tax to 13 months, these two figures corresponding to the highest values in our sample.

the relative price appreciates less than that predicted by the standard neoclassical model abstracting from labor market frictions. Our estimates also reveal that the unemployment rate of tradables falls more than that of non tradables since the appreciation in the relative price of non tradables does not compensate for lower productivity gains. We also report evidence suggesting that such responses to a productivity differential have increased as the result of decreasing labor mobility costs. Whilst time-varying costs of switching sectors can rationalize the rise in the responses of variables to higher relative productivity, our estimates reveal that their adjustment is quite distinct whether labor market regulation is high or low. We report results which indicate that both the relative wage and the unemployment differential fall more while the relative price appreciates less in countries with more regulated labor markets.

To account for the evidence, we develop a two-sector open economy model with search in the labor market and an endogenous sectoral labor force participation decision. As in Alvarez and Shimer [2011], workers cannot reallocate hours worked from one sector to another without searching for a job in this sector. Because such an activity is costly in utility terms, workers experience a switching cost. We find analytically that two sets of parameters play a pivotal role in the determination of the relative wage and relative price responses to higher productivity in tradables relative to non tradables: i) preference parameters such as the elasticity of labor supply at the extensive margin and the elasticity of substitution in consumption between tradables and non tradables, ii) parameters capturing labor market institutions such as the firing tax, the unemployment benefit replacement rate and the worker bargaining power.

Our quantitative analysis indicates that, regardless of the value of the elasticity of substitution between tradables and non tradables, when the elasticity of labor at the extensive margin takes finite values, the relative wage falls while workers' mobility costs curtail the appreciation in the relative price following a productivity differential, thus producing a fall in the unemployment rate differential between tradables and non tradables. On the contrary, the situations of total immobility or perfect mobility of labor across sectors that emerge as special cases cannot account for the evidence. When we investigate the impact of labor market institutions, we find that the relative price appreciates less when raising the replacement rate or the worker bargaining power because net exports and thus demand for tradables increase more. Moreover, the relative wage falls by a larger amount because traded firms are encouraged to hire more, thus amplifying the rise in the traded wage along with the decline in the relative unemployment rate of tradables. Increasing the firing cost curbs hiring in the non traded sector, and thus produces a larger decline in the relative wage, in accordance with our evidence. Because strictness of legal protection against dismissals further biases the positive influence of the productivity shock on traded firms' hirings, the unemployment rate of tradables decreases more relative to that of non tradables. Since non

traded output increases less, the relative price of non tradables must appreciate more to clear the goods market.

To explore quantitatively the implications of labor market institutions for the cross-country dispersion in the estimated effects, we calibrate the model to country-specific data. We thus allow for the elasticity of substitution between tradables and non tradables and labor market parameters to vary across countries. Whilst simulated responses display a wide dispersion across countries, both the relative wage and the unemployment rate differential decline more in countries where labor market regulation is higher, in line with the evidence. The relative price of non tradables also appreciates less in countries where labor markets are more regulated, in accordance with the empirical findings, the strictness of legal protection against dismissals playing a secondary role in determining the movements in the relative price.

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Table 1: Panel Cointegration Estimates of β and γ for the Whole Sample (eqs. (7))

	Relative wage eq. (7a)		Relative price eq. (7b)	
	DOLS	FMOLS	DOLS	FMOLS
$(a^T - a^N)$	-0.223 ^a (-29.72)	-0.223 ^a (-33.85)	0.646 ^a (76.54)	0.636 ^a (83.01)
$t(\beta) = 0$	0.000	0.000		
$t(\gamma) = 1$			0.000	0.000
Number of countries	18	18	18	18
Number of observations	680	680	680	680

Notes: all regressions include country fixed effects. Heteroskedasticity and autocorrelation consistent t-statistics are reported in parentheses. ^a denotes significance at 1% level. The rows $t(\beta) = 0$ and $t(\gamma) = 1$ report the p-value of the test of $H_0 : \beta = 0$ and $H_0 : \gamma = 1$ respectively.

Table 2: Panel Cointegration Estimates of β_i and γ_i for Each Country (eqs. (7))

Country	Relative wage equation		Relative price equation	
	$\hat{\beta}_i^{DOLS}$	$\hat{\beta}_i^{FMOLS}$	$\hat{\gamma}_i^{DOLS}$	$\hat{\gamma}_i^{FMOLS}$
AUS	-0.047 (-1.51)	-0.062 ^b (-2.19)	0.567 ^a (10.95)	0.559 ^a (10.88)
AUT	-0.220 ^a (-12.62)	-0.231 ^a (-13.95)	0.687 ^a (20.14)	0.689 ^a (21.89)
BEL	-0.150 ^a (-6.36)	-0.135 ^a (-5.74)	0.732 ^a (17.49)	0.740 ^a (17.52)
CAN	-0.298 ^a (-6.11)	-0.299 ^a (-7.19)	0.549 ^a (4.95)	0.524 ^a (5.19)
DEU	-0.502 ^a (-20.60)	-0.493 ^a (-22.90)	0.532 ^a (9.76)	0.517 ^a (10.70)
DNK	-0.366 ^a (-4.96)	-0.355 ^a (-5.86)	0.361 ^a (9.51)	0.357 ^a (12.63)
ESP	-0.231 ^a (-8.30)	-0.236 ^a (-11.10)	0.689 ^a (19.14)	0.709 ^a (21.50)
FIN	-0.197 ^a (-11.14)	-0.193 ^a (-12.99)	0.645 ^a (19.98)	0.628 ^a (23.02)
FRA	-0.396 ^a (-6.56)	-0.395 ^a (-7.00)	0.787 ^a (29.79)	0.790 ^a (31.01)
GBR	-0.152 ^b (-2.35)	-0.161 ^a (-2.94)	0.842 ^a (6.63)	0.810 ^a (7.41)
IRL	-0.187 ^a (-3.64)	-0.193 ^a (-4.20)	0.554 ^a (18.09)	0.562 ^a (19.20)
ITA	-0.265 ^a (-10.04)	-0.282 ^a (-11.74)	0.761 ^a (23.91)	0.727 ^a (23.34)
JPN	-0.161 ^a (-8.05)	-0.157 ^a (-9.29)	0.879 ^a (42.50)	0.898 ^a (41.06)
KOR	-0.403 ^a (-10.77)	-0.393 ^a (-12.53)	0.529 ^a (40.46)	0.532 ^a (45.58)
NLD	-0.331 ^a (-5.90)	-0.307 ^a (-5.82)	0.724 ^a (15.95)	0.731 ^a (18.04)
NOR	-0.071 ^a (-5.84)	-0.081 ^a (-6.17)	0.094 (0.75)	0.034 (0.29)
SWE	-0.020 (-0.66)	-0.009 (-0.52)	0.908 ^a (11.23)	0.882 ^a (18.13)
USA	-0.017 (-0.69)	-0.033 (-1.47)	0.784 ^a (23.50)	0.765 ^a (24.80)
EU-12	-0.252 ^a (-26.89)	-0.249 ^a (-30.24)	0.685 ^a (58.20)	0.679 ^a (64.78)
All sample	-0.223 ^a (-29.72)	-0.223 ^a (-33.85)	0.646 ^a (76.54)	0.636 ^a (83.01)

Notes: Heteroskedasticity and autocorrelation consistent t-statistics are reported in parentheses. ^a, ^b and ^c denote significance at 1%, 5% and 10% levels.

Table 3: Panel OLS Estimates of σ for the Whole and Sub-Samples (eq. (8))

	Relative unemployment eq. (8)			
	Without control (1)	with EPL_{adj} (2)	with ϱ (3)	with EPL_{adj} and ϱ (4)
σ	-0.034 ^a (-2.58)	-0.034 ^a (-2.62)	-0.037 ^a (-2.85)	-0.037 ^a (-2.64)
σ^H	-0.036 ^c (-1.77)	-0.036 ^c (-1.71)	-0.040 ^c (-1.90)	-0.041 ^c (-1.95)
σ^L	-0.033 ^c (-1.86)	-0.031 ^c (-1.72)	-0.034 ^c (-1.89)	-0.032 ^c (-1.68)
Number of observations	164	164	164	164
Number of countries	14	14	14	14

Notes: all regressions include country fixed effects. ^a (^c) denotes significance at 1% (10%) level. We split the sample of 14 OECD countries into two subsamples on the basis of the mean sample of the labor market regulation ('LMR') index obtained by using a principal component analysis. The number of observations of the sub-sample of countries with high (low) labor market regulation is 94 (70). We estimate eq. (8) for the high and low labor market regulation countries without (column 1) or with one (columns 2 and 3) or two (column 4) labor market control variable; coefficient σ^H (σ^L) captures the response of the unemployment rate differential between tradables and non tradables in countries with high (low) labor market regulation. 'EPL_{adj}' is the strictness of employment protection against dismissals adjusted with the share of permanent workers, ' ϱ ' is the unemployment benefits replacement rate.

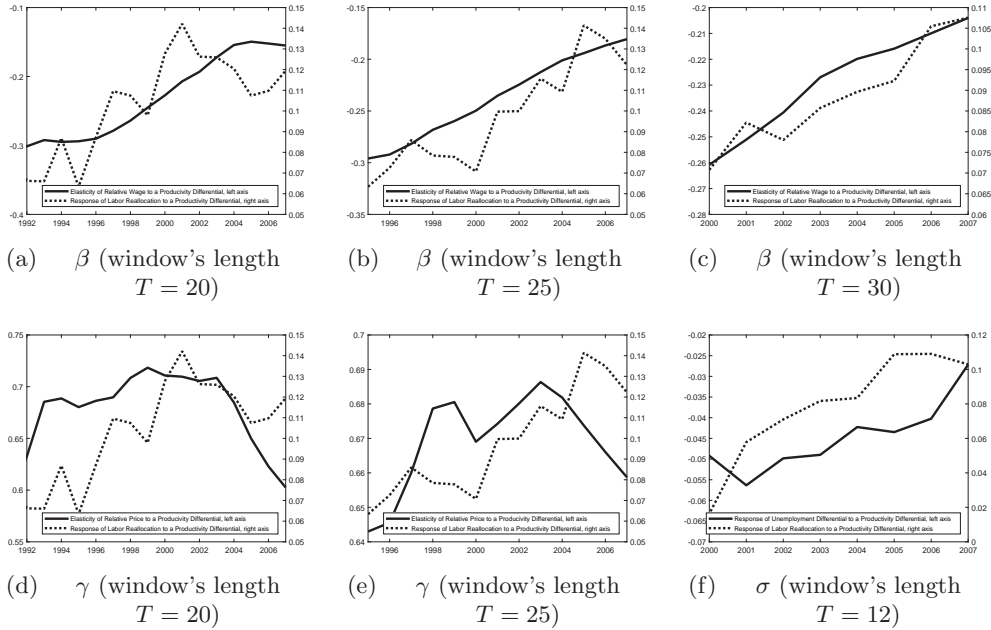


Figure 1: Plot of Estimates of β , γ , and σ in Rolling Sub-Samples against the Magnitude of Intersectoral Labor Reallocation Caused by Higher Productivity Gains in Tradables Notes: We estimate β (see eq. (7a)), γ (see eq. (7b)), σ (see eq. (8)), and the extent of labor reallocation following higher relative productivity in rolling sub-samples. The first row of Figure 1 plots FMOLS estimates for the response of the relative wage to a rise in the relative productivity of tradables (shown in the solid line) against the magnitude of intersectoral labor reallocation following a rise in the productivity differential (shown in the dashed line). The first two figures in the second row of Figure 1 plot FMOLS estimates for the response of the relative price to a rise in the relative productivity of tradables (shown in the solid line) against the magnitude of intersectoral labor reallocation following a rise in the productivity differential (shown in the dashed line). Sample: 18 OECD countries, 1970-2007. Figure 1(f) plots the estimated response of the unemployment rate differential to a rise in the productivity differential (shown in the solid line) against the magnitude of intersectoral labor reallocation following a rise in the productivity differential (shown in the dashed line). Sample: 10 OECD countries, 1987-2007.

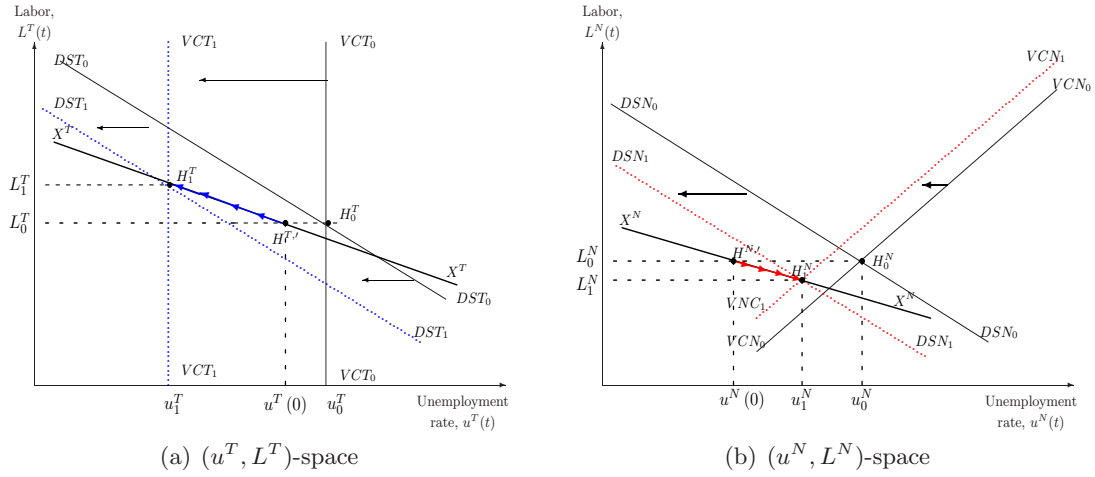
Table 4: Panel Cointegration Estimates of β and γ for Sub-Samples

LMR	ϱ		BargCov		EPL _{adj}		LMR	
	DOLS	FMOLS	DOLS	FMOLS	DOLS	FMOLS	DOLS	FMOLS
A.Relative Wage								
β^H	-0.261 ^a (-23.04)	-0.255 ^a (-25.65)	-0.242 ^a (-22.18)	-0.238 ^a (-24.91)	-0.165 ^a (-30.29)	-0.172 ^a (-32.59)	-0.166 ^a (-31.68)	-0.173 ^a (-33.20)
β^L	-0.158 ^a (-16.34)	-0.166 ^a (-19.14)	-0.180 ^a (-17.25)	-0.185 ^a (-19.93)	-0.130 ^a (-13.97)	-0.130 ^a (-11.57)	-0.113 ^a (-10.74)	-0.112 ^a (-8.26)
$t(\hat{\beta}^L = \hat{\beta}^H)$	0.000	0.000	0.000	0.000	0.000	0.011	0.000	0.000
B.Relative Price								
γ^H	0.791 ^a (6.37)	0.776 ^a (7.15)	0.555 ^a (8.76)	0.566 ^a (9.41)	0.501 ^a (5.37)	0.414 ^a (4.75)	0.257 ^a (3.10)	0.186 ^b (2.02)
γ^L	1.123 ^a (12.81)	1.037 ^a (13.60)	1.388 ^a (10.28)	1.273 ^a (11.21)	0.205 ^b (2.40)	0.236 ^a (2.91)	0.502 ^a (4.91)	0.524 ^a (6.01)
$t(\hat{\gamma}^L = \hat{\gamma}^H)$	0.000	0.000	0.000	0.000	1.000	0.987	0.011	0.000
Time period	1970-2007		1970-2007		1985-2007		1985-2007	
Countries	17		17		18		17	
Observations	642		642		414		390	
mean LMR (high)	0.609		0.864		2.280		1.376	
mean LMR (low)	0.391		0.491		1.296		-0.512	

Notes: ^a denotes significance at 1% level. To investigate whether labor market regulation influences the responses of the relative wage, β , and the relative price, γ , to a productivity differential, we split the sample of 18 OECD countries into two subsamples and run the regressions (7a)-(7b) for the high and low-labor market regulation countries. β^H (β^L) and γ^H (γ^L) capture the responses of the relative wage and the relative price, respectively, in countries with high (low) labor market regulation. The row $t(\hat{\beta}^L = \hat{\beta}^H)$ ($t(\hat{\gamma}^L = \hat{\gamma}^H)$) reports the p-value of the test of $H_0 : \hat{\beta}^L = \hat{\beta}^H$ ($\hat{\gamma}^L = \hat{\gamma}^H$). 'ϱ' is the unemployment benefits replacement rate, 'EPL_{adj}' the strictness of employment protection against dismissals adjusted with the share of permanent workers, 'BargCov' the bargaining coverage and 'LMR' the labor market regulation index obtained by using a principal component analysis.

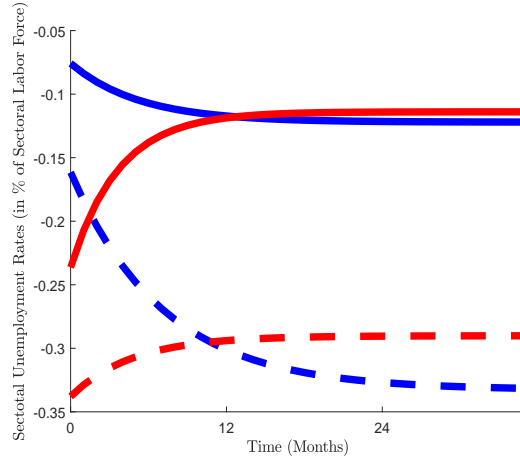
Table 5: Data to Calibrate the Two-Sector Model (1990-2007)

Countries	Non tradable Share			G^j/Y^j			Relative Productivity
	Labor (1)	Consumption (2)	Gov. Spending (3)	G/Y (4)	G^T/Y^T (5)	G^N/Y^N (6)	A^T/A^N (7)
AUS	0.68	0.43	n.a.	0.18	n.a.	n.a.	1.30
AUT	0.64	0.42	0.90	0.19	0.05	0.27	1.05
BEL	0.68	0.42	0.91	0.22	0.06	0.30	1.28
CAN	0.69	0.43	0.91	0.20	0.05	0.30	1.32
DEU	0.65	0.40	0.91	0.19	0.05	0.27	1.00
DNK	0.68	0.42	0.94	0.26	0.05	0.36	1.17
ESP	0.66	0.46	0.88	0.18	0.06	0.24	1.18
FIN	0.63	0.43	0.89	0.22	0.06	0.34	1.47
FRA	0.69	0.40	0.94	0.23	0.05	0.31	1.05
GBR	0.70	0.40	0.93	0.20	0.04	0.29	1.54
IRL	0.62	0.43	0.89	0.17	0.04	0.28	1.83
ITA	0.63	0.37	0.91	0.19	0.05	0.27	1.00
JPN	0.64	0.43	0.86	0.16	0.06	0.22	0.96
KOR	0.58	0.44	0.76	0.12	0.06	0.18	1.53
NLD	0.70	0.40	0.90	0.23	0.07	0.32	1.38
NOR	0.66	0.39	0.88	0.21	0.06	0.34	1.44
SWE	0.68	0.45	0.92	0.27	0.06	0.39	1.42
USA	0.73	0.51	0.90	0.16	0.05	0.20	1.12
EU-12	0.66	0.42	0.91	0.21	0.05	0.30	1.28
Mean	0.66	0.42	0.90	0.20	0.05	0.29	1.28



(a) (u^T, L^T) -space

(b) (u^N, L^N) -space



(c) Dynamics for $u^T(t)$ and $u^N(t)$

Figure 2: Theoretical and Numerically Computed Adjustment of Sectoral Unemployment Rates. *Notes:* Figure 2(c) plots the dynamics of unemployment rates of tradables (shown in the blue line) and non tradables (shown in the red line) for a representative OECD economy (shown in solid lines) and contrast them with those for an OECD economy with high labor market regulation (shown in dashed lines), i.e., we set the unemployment benefit replacement rate to 78.2% and the firing tax to 13 months.

Table 6: Data to Calibrate the Labor Market

Country	Period (1)	u^T (2)	u^N (3)	u (4)	m^T (5)	s^T (6)	m^N (7)	s^N (8)	Period (9)	θ^T (10)	θ^N (11)	Period (12)	θ (13)	ϱ (14)	τ (15)
AUS	95-07	0.072	0.062	0.065	0.304	0.0236	0.278	0.0184				80-07	0.13	52.4	1.9
AUT	94-07	0.037	0.044	0.042	0.126	0.0048	0.123	0.0057	04-05	0.17	0.27	80-07	0.18	52.8	6.6
BEL	01-07	0.077	0.079	0.078	0.067	0.0056	0.064	0.0055				82-03	0.05	65.2	5.7
CAN	87-07	0.082	0.084	0.083	0.269	0.0241	0.269	0.0247	06-07	0.21	0.40	80-07	0.09	52.9	2.8
DEU	95-07	0.101	0.091	0.094	0.067	0.0075	0.062	0.0062						60.6	3.4
DNK	94-04	0.064	0.061	0.062	0.245	0.0167	0.247	0.0161						78.2	4.5
ESP	92-07	0.147	0.161	0.156	0.097	0.0167	0.094	0.0181				80-04	0.03	47.2	9.4
FIN	91-07	0.087	0.118	0.107	0.137	0.0130	0.135	0.0180	02-07	0.21	0.2	81-07	0.09	65.1	3.9
FRA	75-04	n.a.	n.a.	0.081	0.067	0.0059	0.067	0.0059				89-07	0.07	51.8	3.7
GBR	88-07	0.073	0.066	0.068	0.163	0.0129	0.161	0.0114	01-07	0.30	0.48	80-07	0.24	58.3	2.9
IRL	86-97	0.130	0.154	0.144	0.048	0.0071	0.045	0.0082						58.2	2.0
ITA	93-07	0.094	0.098	0.097	0.062	0.0065	0.059	0.0064						10.1	1.7
JPN	03-07	0.033	0.033	0.033	0.171	0.0058	0.165	0.0056				80-07	0.27	50.1	3.8
KOR	92-07	0.027	0.041	0.035	0.262	0.0072	0.262	0.0112						37.5	13.0
NLD	83-04	n.a.	n.a.	0.064	0.047	0.0032	0.047	0.0032						68.2	3.0
NOR	83-04	n.a.	n.a.	0.045	0.305	0.0143	0.305	0.0143				80-07	0.18	53.5	2.0
SWE	95-07	0.056	0.060	0.059	0.233	0.0138	0.231	0.0148	05-07	0.17	0.17	82-07	0.19	54.9	4.8
USA	03-07	0.048	0.053	0.052	0.444	0.0224	0.440	0.0246	01-07	0.43	0.65	01-07	0.59	26.1	0.0
Average EU-12		0.087	0.093	0.091	0.124	0.0118	0.122	0.0125		0.21	0.30		0.12	55.9	4.3
Average OECD		0.079	0.083	0.081	0.174	0.0148	0.170	0.0154		0.24	0.34		0.18	52.4	4.2

Notes: Regarding sectoral unemployment rates, job finding and separation rates for DNK, the period 1994-2004 has to be read 1994-1998 and 2002-2004; u^j is the sectoral unemployment rate (source: ILO); m^j and s^j are the monthly job finding and job destruction rates in sector $j = T, N$, respectively (source: ILO); the monthly job destruction rate has been estimated by adopting the methodology developed by Shimer [2012] except for FRA, NLD, NOR and KOR; θ^j is the labor market tightness in sector j (source: Eurostat for European countries, Labour Market Statistics from the Office for National Statistics for the U.K., Bureau of Labor Statistics for the U.S.); ϱ is the average net unemployment benefit replacement rate over the period 1980-2007 (source: OECD Benefits and Wages Database); τ (with $x = \tau W$) is the firing cost expressed in monthly salary equivalents and is averaged over the period 1980-2005 (source: Fondazione De Benedetti).

Table 7: Decomposition of Long-Term Responses to Higher Productivity in Tradables Relative to Non Tradables

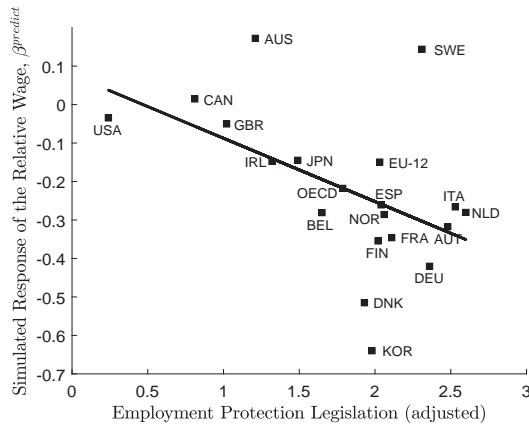
	BS	OECD	Labor force		Bargaining power	Replacement rate	Firing	EU-12	US	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	$(u = 0)$	$(u = 8.1\%)$	$(\sigma_L = 0)$	$(\sigma_L = 0.2)$	$(\sigma_L = 1)$	$(\alpha w = 0.9)$	$(\varrho = 0.782)$	$(\tau = 13)$	$(u = 9.1\%)$	$(u = 5.2\%)$
$\phi = 1$										
A.Relative Wage										
Relative wage, $\hat{\omega}$	0.00	-0.31	-0.59	-0.43	-0.25	-0.35	-0.37	-0.34	-0.34	-0.25
Labor market frictions effect	0.00	-0.02	-0.04	-0.02	-0.02	-0.03	-0.03	-0.06	-0.03	-0.00
Labor accumulation effect	0.00	-0.29	-0.55	-0.42	-0.22	-0.32	-0.34	-0.28	-0.31	-0.24
B.Relative Price										
Relative price, \hat{p}	1.00	0.70	0.42	0.57	0.77	0.66	0.63	0.73	0.67	0.74
Labor market frictions effect	0.00	1.01	0.99	1.01	1.01	1.01	1.00	1.04	1.01	1.00
Labor accumulation effect	0.00	-0.31	-0.57	-0.44	-0.24	-0.34	-0.37	-0.30	-0.32	-0.24
C.Relative Unemployment										
Unemployment differential, $du^T - du^N$	0.00	-0.01	-0.03	-0.03	0.00	-0.03	-0.05	-0.02	-0.02	-0.00
Labor market frictions effect	0.00	0.01	0.00	-0.01	0.02	0.01	0.01	0.00	0.01	0.00
Labor accumulation effect	0.00	-0.02	-0.03	-0.02	-0.02	-0.04	-0.06	-0.02	-0.03	-0.01
$\phi < 1$										
D.Relative Wage										
Relative wage, $\hat{\omega}$	0.00	-0.16	-0.48	-0.20	-0.14	-0.21	-0.25	-0.19	-0.20	-0.09
Labor market frictions effect	0.00	0.29	0.52	0.45	0.21	0.27	0.25	0.25	0.28	0.32
Labor accumulation effect	0.00	-0.45	-1.00	-0.64	-0.35	-0.47	-0.50	-0.44	-0.48	-0.40
E.Relative Price										
Relative price, \hat{p}	1.00	0.85	0.53	0.82	0.88	0.81	0.76	0.89	0.82	0.90
Labor market frictions effect	0.00	1.33	1.57	1.49	1.26	1.31	1.30	1.37	1.33	1.32
Labor accumulation effect	0.00	-0.47	-1.03	-0.66	-0.37	-0.49	-0.54	-0.47	-0.49	-0.40
$\phi > 1$										
F.Relative Wage										
Relative wage, $\hat{\omega}$	0.00	-0.44	-0.68	-0.58	-0.36	-0.47	-0.47	-0.47	-0.46	-0.39
Labor market frictions effect	0.00	-0.25	-0.34	-0.30	-0.22	-0.25	-0.24	-0.29	-0.25	-0.24
Labor accumulation effect	0.00	-0.19	-0.34	-0.29	-0.14	-0.23	-0.24	-0.18	-0.21	-0.15
G.Relative Price										
Relative price, \hat{p}	1.00	0.57	0.32	0.42	0.65	0.54	0.52	0.59	0.54	0.60
Labor market frictions effect	0.00	0.77	0.68	0.72	0.81	0.78	0.78	0.79	0.77	0.76
Labor accumulation effect	0.00	-0.21	-0.36	-0.31	-0.16	-0.24	-0.26	-0.20	-0.22	-0.15

Notes: Effect of a rise in labor productivity of tradables relative to non tradables by 1%. Panels A and B show the deviation in percentage relative to steady-state for the relative wage of non traded workers $\omega \equiv w^N - w^T$ and the relative price of non tradables $p \equiv p^N - p^T$, respectively, and break down changes in a labor market frictions effect (keeping unchanged net exports), and a labor accumulation effect (triggered by the long-run adjustment in net exports). Panel C shows the change in the unemployment rate differential between tradables and non tradables in percentage point. While panels A, B, C show the results when setting ϕ to one, panels D and E show results for $\phi < 1$ and panels F and G give results for $\phi > 1$; ϕ is the elasticity of substitution in consumption between tradables and non tradables; σ_L is the elasticity of labor supply at the extensive margin; αw corresponds to the worker bargaining power; ϱ is the unemployment benefits replacement rate; τ is the firing tax expressed in monthly salary equivalents. In our baseline calibration we set $\phi = 1$, $\sigma_L = 0.6$, $\alpha w = 0.6$, $\varrho = 0.524$, $\tau = 4.2$.

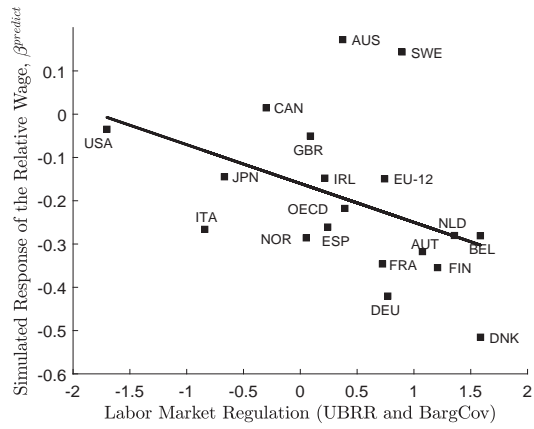
Table 8: Cross-Country Analysis

Country	Parameter	Relative wage response		Relative price response		Unemployment differential			
Country	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Substitutability ϕ	$\hat{\omega}^{predict}$	$\hat{\omega}^{FMOLS}$	(3)-(2)	$\hat{p}^{predict}$	\hat{p}^{FMOLS}	(6)-(5)	$\hat{\sigma}^{predict}$	$(du^T - du^N)_{\sigma_t \rightarrow \infty}$
AUS	0.295	0.172	-0.062	-0.234	1.166	0.559	-0.607	0.002	-0.016
AUT	1.019	-0.318	-0.231	0.087	0.684*	0.689	0.005	-0.006	0.010
BEL	0.749	-0.281	-0.135	0.146	0.715*	0.740	0.025	-0.023	-0.000
CAN	0.439	0.015	-0.299	-0.314	1.011	0.524	-0.487	0.003	0.001
DEU	1.126	-0.420	-0.493	-0.073	0.562*	0.517	-0.045	-0.047	-0.020
DNK	1.925	-0.515	-0.355	0.160	0.468	0.357	-0.111	-0.061	-0.012
ESP	0.782	-0.261*	-0.236	0.025	0.750*	0.709	-0.041	-0.020	0.009
FIN	1.043	-0.355	-0.193	0.162	0.638*	0.628	-0.010	-0.014	0.056
FRA	0.896	-0.346*	-0.395	-0.049	0.645	0.790	0.145	-0.022	-0.000
GBR	0.477	-0.050*	-0.161	-0.111	0.944*	0.810	-0.134	-0.009	-0.014
IRL	0.321	-0.148*	-0.193	-0.045	0.844	0.562	-0.282	0.000	0.035
ITA	-	-0.266*	-0.282	-0.016	0.729*	0.727	-0.002	-0.009	0.003
JPN	0.713	-0.145*	-0.157	-0.012	0.853	0.898	0.045	-0.004	-0.001
KOR	2.914	-0.640	-0.393	0.247	0.373	0.532	0.164	-0.008	0.015
NLD	0.644	-0.280*	-0.307	-0.027	0.706*	0.731	0.025	-0.022	-0.001
NOR	1.004	-0.286	-0.081	0.205	0.703	0.034	-0.669	-0.009	0.003
SWE	0.329	0.144	-0.009	-0.153	1.152	0.882	-0.270	0.011	0.005
USA	0.699	-0.035*	-0.033	0.002	0.974	0.765	-0.209	0.002	0.005
EU-12	0.599	-0.149	-0.249	-0.100	0.849	0.679	-0.170	-0.007	0.006
Whole sample	0.800	-0.218*	-0.223	-0.005	0.778	0.636	-0.142	-0.011	0.005
CORR	-	-	-	0.72	-	-	0.34	-	-

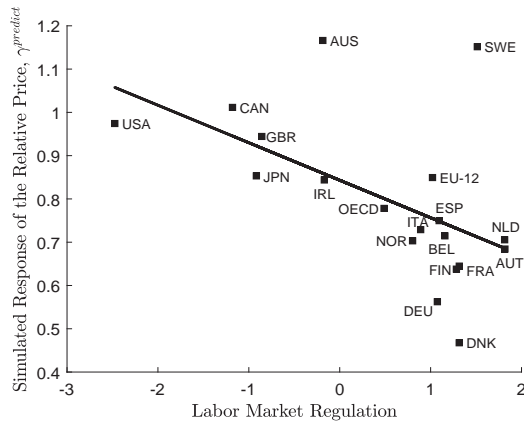
Notes: ϕ is the intratemporal elasticity of substitution between traded goods and non traded goods; because estimates of ϕ for Italy are inconsistent, its value is left blank. We denote by superscripts 'predict' and 'FMOLS' the numerically computed values and fully modified OLS estimates taken from Table 2, respectively; columns (4) and (7) show the difference between FMOLS estimates and predicted values for percentage changes in the relative wage and the relative price of non tradables. * indicates that the predicted value falls in the confidence interval; we calculate 99% confidence intervals based on estimated standard deviations of β and γ obtained when running the regression (7a) and (7b), respectively, for each country, EU-12 and the whole sample. The last line 'CORR' shows the correlation coefficient between simulated and estimated responses of the relative wage and the relative price for the 18 OECD countries in our sample. When computing the response of the unemployment differential to a rise in productivity of tradables relative to non tradables by 1%, shown in column 8, we adjust numerically computed values with a term that captures the extent to which search frictions vary across sectors, as for p and ω . This correction allows us to map the numerically computed response of the unemployment differential into its estimated counterpart, σ .



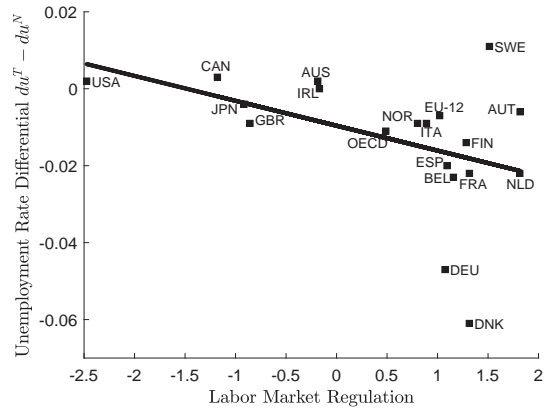
(a) Relative Wage Responses against EPL_{adj}



(b) Relative Wage Responses against Unemployment Benefits and Bargaining Coverage



(c) Relative Price Responses against Labor Market Regulation



(d) Unemployment Rate Differential against Labor Market Regulation

Figure 3: Cross-Country Relationship between Simulated Responses to Higher Relative Productivity and Labor Market Regulation. Notes: Horizontal axes display the indicators of labor market regulation: the top-left panel shows the employment protection legislation index adjusted with the share of permanent workers (i.e., EPL_{adj}), the top-right panel shows a labor market regulation index obtained by using a principal component analysis which encompasses both the generosity of the unemployment benefit scheme (UBRR) and the extent of the worker bargaining power (BargCov), the bottom panels show the labor market regulation index which encompasses the three dimensions of labor market institutions. Vertical axes in the top panels report simulated long-run responses of the relative wage to higher relative productivity from the baseline model with search frictions and an endogenous labor force participation decision. Vertical axes in bottom panels report simulated long-run responses of the relative price and unemployment rate differential to higher relative productivity.

A Data for Empirical Analysis

Country Coverage: Our sample consists of a panel of 18 OECD countries: Australia (AUS), Austria (AUT), Belgium (BEL), Canada (CAN), Germany (DEU), Denmark (DNK), Spain (ESP), Finland (FIN), France (FRA), the United Kingdom (GBR), Ireland (IRL), Italy (ITA), Japan (JPN), Korea (KOR), the Netherlands (NLD), Norway (NOR), Sweden (SWE), and the United States (USA).

Period Coverage: The period is running from 1970 to 2007, except for Japan (1974-2007).

Sources: We use the EU KLEMS [2011] database (the March 2011 data release) for all countries of our sample with the exceptions of Canada and Norway. For these two countries, sectoral data are taken from the Structural Analysis (STAN) database provided by the OECD [2011]. Both the EU KLEMS and STAN databases provide annual data at the ISIC-rev.3 1-digit level for eleven industries.

The eleven industries are split into tradables and non tradables sectors. To do so, we adopt the classification proposed by De Gregorio et al. [1994]. Following Jensen and Kletzer [2006], we have updated this classification by treating "Financial Intermediation" as a traded industry. We construct traded and non traded sectors as follows (EU KLEMS codes are given in parentheses):

- **Traded Sector:** "Agriculture, Hunting, Forestry and Fishing" (A-B), "Mining and Quarrying" (C), "Total Manufacturing" (D), "Transport, Storage and Communication" (I) and "Financial Intermediation" (J).
- **Non Traded Sector:** "Electricity, Gas and Water Supply" (E), "Construction" (F), "Wholesale and Retail Trade" (G), "Hotels and Restaurants" (H), "Real Estate, Renting and Business Services" (K) and "Community Social and Personal Services" (L-Q).

Once industries have been classified as traded or non traded, for any macroeconomic variable X , its sectoral counterpart X^j for $j = T, N$ is constructed by adding the X_k of all sub-industries k classified in sector $j = T, N$ as follows $X^j = \sum_{k \in j} X_k$. In the following, we provide details on data construction (mnemonics are in parentheses):

- **Relative wage of non tradables**, Ω , is calculated as the ratio of the nominal wage in the non traded sector W^N to the nominal wage in the traded sector W^T , i.e., $\Omega = W^N/W^T$. The sectoral nominal wage W^j for sector $j = T, N$ is calculated by dividing labor compensation in sector j (LAB) by total hours worked by persons engaged (H_EMP) in that sector.
- **Relative price of non tradables**, P , corresponds to the ratio of the value added deflator of non traded goods P^N to the value added deflator of traded goods P^T , i.e., $P = P^N/P^T$. The value added deflator P^j for sector $j = T, N$ is calculated by dividing value added at current prices by value added at constant prices in sector j . Series for sectoral value added at current prices (VA) (constant prices (VA_QI) resp.) are constructed by adding value at current (constant resp.) prices of all sub-industries in sector $j = T, N$.
- **Relative productivity of tradables**, A^T/A^N , is calculated as the ratio of traded real labor productivity A^T to the non traded real labor productivity A^N . To measure real labor productivity in sector $j = T, N$, we divide value-added at constant prices in sector j (VA_QI) by total hours worked by persons engaged (H_EMP) in that sector.
- The construction of **sectoral unemployment rates** is detailed below in subsection B.3.

To empirically assess the role of labor market regulation in the determination of the relative price and relative wage responses to higher productivity in tradables relative to non tradables, we use a number of indicators which capture the extent of rigidity of labor markets. We detail below the sources:

- **Employment protection legislation**, denoted by EPL , is an index available on an annual basis developed by the OECD which is designed as a multi-dimensional indicator of the strictness of a comprehensive set of legal regulations governing hiring and firing employees on regular contracts. Source: OECD Labour Market Statistics database. Data coverage: 1985-2007 (1990-2007 for KOR). Because the legal protection for workers with temporary contracts has been eased in most European countries, we follow Boeri and Van Ours [2008] and construct an alternative index in order to have a more accurate measure of employment protection. This indicator, denoted by EPL_{adj} , is computed by adjusting EPL with the share of permanent workers in the economy ($share_{perm}$) according to $EPL_{adj} = EPL \times share_{perm}$. Source for $share_{perm}$: OECD Labour Market Statistics database. Data coverage: 1985-2007 (1990-2007 for KOR).
- The generosity of the unemployment benefit scheme is commonly captured by the **unemployment benefit replacement rate**. The replacement rate, denoted by ρ , measure is defined as

the average of the net unemployment benefit (including social assistance and housing benefit) replacement rates for two earnings levels and three family situations, and for three durations of unemployment (1 year, 2&3 years, 4&5 years). Source: OECD, Benefits and Wages Database. Data coverage: 2001-2007. In order to have longer time series, we calculated ρ over the period running from 1970 to 2000, by using the growth rate of the historic OECD measure of benefit entitlements which is defined as the average of the gross unemployment benefit replacement rates for two earnings levels, three family situations and three durations of unemployment. Source: OECD, Benefits and Wages Database. Data coverage: 1970-2001 for all countries while data are unavailable for Korea.

- The worker bargaining power is measured by the **collective bargaining coverage** which corresponds to the employees covered by collective wage bargaining agreements as a proportion of all wage and salary earners in employment with the right to bargaining. This time-varying indicator is denoted by BargCov. Source: Data Base on Institutional Characteristics of Trade Unions, Wage Setting, State Intervention and Social Pacts, 1960-2009 (ICTWSS), version 3.0, Jelle Visser [2009]. Data coverage: 1970-2007 for AUS, AUT, CAN, DEU, DNK, FIN, GBR, IRL, ITA, JPN, SWE and USA, 1970-2005 for NLD and NOR, 1970-2002 for BEL and FRA, 1977-2004 for ESP and 2002-2006 for KOR.

Figures 4(a), 4(b), 4(c) plot the absolute values of FMOLS estimates for the relative wage responses, β_i , taken from Table 2 against the EPL index adjusted with the share of permanent workers, the net unemployment benefit replacement rates, and the bargaining coverage, respectively. Because time series for the unemployment benefit replacement rate and bargaining coverage are available only from the beginning of the 2000's for Korea and thus are too short, we exclude this country from Figures 4(b) and 4(c). In line with our conjecture, the trend lines in Figures 4(a), 4(b), 4(c) show that the estimated responses of the relative wage and our three measures of labor market regulation are positively related across countries. We also we have recourse to a principal component analysis to construct an indicator that gives a more accurate measure of the degree of labor market regulation. Figure 4(d) displays the traditional distinction between English-speaking and Continental European economies, labor markets being much less regulated in the former than the latter countries. Importantly, in accordance with our conjecture, the trend line is upward sloping, thus suggesting that higher productivity in tradables relative to non tradables lowers the relative wage more in countries where labor market regulation is more pronounced.

B Data for Calibration

B.1 Non Tradable Share

Table 5 shows the non-tradable content of labor, consumption, government spending, and gives the share of government spending on the traded and non traded goods in the sectoral output. The last column of Table 5 also shows the ratio of traded real labor productivity to the non traded real labor productivity, A^T/A^N . Our sample consists of 18 OECD countries mentioned in section A, including 12 European countries plus Australia, Canada, Korea, Japan, Norway, the United-States. Our reference period for the calibration corresponds to the period 1990-2007. The choice of this period has been dictated by data availability.

To calculate the non tradable share of employment we split the eleven industries into traded and non traded sectors by adopting the classification proposed by De Gregorio et al. [1994] and updated by Jensen and Kletzer [2006] (Source: EU KLEMS [2011]). The non-tradable share of labor, shown in column 1 of Table 5 averages to 66%.

To split consumption expenditure (at current prices) into consumption in traded and non traded goods, we made use of the Classification of Individual Consumption by Purpose (COICOP) published by the United Nations (Source: United Nations [2011]). Among the twelve items, the following ones are treated as consumption in traded goods: "Food and Non-Alcoholic Beverages", "Alcoholic Beverages Tobacco and Narcotics", "Clothing and Footwear", "Furnishings, Household Equipment", "Transport", "Miscellaneous Goods and Services". The remaining items are treated as consumption in non traded goods: "Housing, Water, Electricity, Gas and Fuels", "Health", "Communication", "Education", "Restaurants and Hotels". Because the item "Recreation and Culture" is somewhat problematic, we decided to consider it as both tradable (50%) and non tradable (50%) with equal shares. Data coverage: 1990-2007 for AUS, AUT, CAN, DNK, FIN, FRA, GBR, ITA, JPN, KOR, NLD, NOR, and USA, 1991-2007 for DEU, 1993-2007 for SWE, 1995-2007 for BEL and ESP and 1996-2007 for IRL. Note that the non-tradable share of consumption shown in column 2 of Table 5 averages to 42%.

Sectoral government expenditure data (at current prices) were obtained from the Government Finance Statistics Yearbook (Source: IMF [2011]) and the OECD General Government Accounts database (Source: OECD [2012b]). Adopting Morshed and Turnovsky's [2004] methodology, the

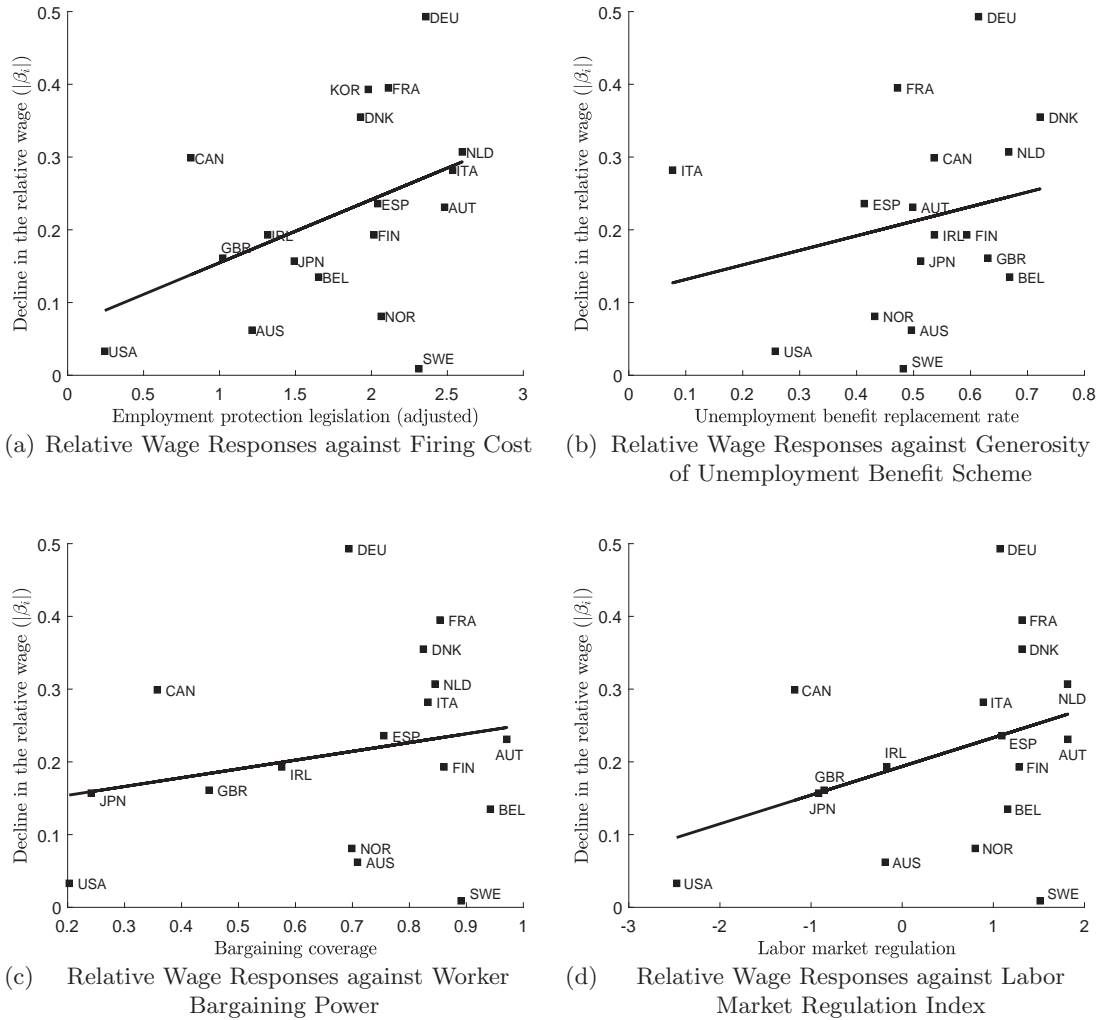


Figure 4: Labor Market Regulation and The Relative Wage Response to Higher Productivity of Tradables relative to Non Tradables Notes: Figure 4 plots fully modified OLS estimates of relative wage responses to a labor productivity differential against indicators of labor market regulation. Horizontal axis displays the FMOLS estimates for each country which are taken from Table 2. For easier reading, we show the absolute value of the change in the relative wage (i.e., $|\beta_i|$). Firing cost is captured by the employment protection legislation index adjusted with the share of permanent workers in the economy (source: OECD); the generosity of unemployment benefit scheme is measured by the average of net unemployment benefit replacement rates for three duration of unemployment (source: OECD); the worker bargaining power is measured by the bargaining coverage (source: Visser [2009]); in Figure 4(d), we have recourse to a principal component analysis in order to have one overall indicator encompassing the three dimensions of labor market regulation.

following four items were treated as traded: "Fuel and Energy", "Agriculture, Forestry, Fishing, and Hunting", "Mining, Manufacturing, and Construction", "Transport and Communications". Items treated as non traded are: "Government Public Services", "Defense", "Public Order and Safety", "Education", "Health", "Social Security and Welfare", "Environment Protection", "Housing and Community Amenities", "Recreation Cultural and Community Affairs". Data coverage: 1990-2007 for BEL, DNK, FIN, GBR, IRL, ITA, JPN, NOR and USA, 1990-2006 for CAN, 1991-2007 for DEU, 1995-2007 for AUT, ESP, FRA, NLD and SWE and 2000-2007 for KOR (data are not available for AUS). The non-tradable component of government spending shown in column 3 of Table 5 averages to 90%. While government spending as a share in GDP is shown in column 4, the proportion of government spending on the traded and non traded good (i.e., G^T/Y^T and G^N/Y^N) are shown in columns 5 and 6 of Table 5. They average 5% and 29%, respectively.

The last column of Table 5 displays the ratio of labor productivity of tradables relative to non tradables (A^T/A^N) averaged over the period 1990-2007 for all countries. Source: the EU KLEMS [2011] and STAN database. As shown in column 7, the traded sector is in average 28 percent more productive than the non traded sector.

B.2 Elasticity of Substitution in consumption (ϕ)

To estimate the elasticity of substitution in consumption ϕ between traded and non traded goods, we first derive a testable equation by inserting the optimal rule for intra-temporal allocation of consumption (15) into the goods market equilibrium which gives $\frac{C^T}{C^N} = \frac{Y^T - NX - E^T}{Y^N - E^N}$ where $NX \equiv \dot{B} - r^*B$ is net exports, $E^T \equiv G^T + I^T + F$ (with $F \equiv \kappa^T V^T + \kappa^N V^N$) and $E^N \equiv G^N + I^N$; note that we include investment in order to be consistent with accounting identities. Inserting the optimal rule for intra-temporal allocation of consumption (15) into the goods market equilibrium, and denoting the ratio of E^T to traded value added adjusted with net exports at current prices by $v_{ET} = \frac{P^T E^T}{P^T Y^T - P^T NX}$, and the ratio of $E^N \equiv G^N + I^N$ to non traded value added at current prices by $v_{EN} = \frac{P^N E^N}{P^N Y^N}$, the goods market equilibrium can be rewritten as follows $\frac{(Y^T - NX)(1 - v_{ET})}{Y^N(1 - v_{EN})} = \left(\frac{\varphi}{1 - \varphi}\right) P^\phi$. Isolating $(Y^T - NX)/Y^N$ and taking logarithm yields $\ln\left(\frac{Y^T - NX}{Y^N}\right) = \alpha + \phi \ln P$ where $\alpha \equiv \ln\left(\frac{1 - v_{ET}}{1 - v_{EN}}\right) + \ln\left(\frac{\varphi}{1 - \varphi}\right)$. Adding an error term μ , we estimate ϕ by running the regression of the (logged) output of tradables adjusted with net exports at constant prices in terms of output of non tradables on the (logged) relative price of non tradables:

$$\ln\left(\frac{Y^T - NX}{Y^N}\right)_{i,t} = f_i + f_t + \alpha_i t + \phi_i \ln P_{i,t} + \mu_{i,t}, \quad (40)$$

where f_i and f_t are the country fixed effects and time dummies, respectively. Because the term α is composed of ratios which may display a trend over time, we add country-specific linear trends, as captured by $\alpha_i t$.

Instead of using time series for sectoral value added, we can alternatively make use of series for sectoral labor compensation. Multiplying both sides of $\frac{(Y^T - NX)(1 - v_{ET})}{Y^N(1 - v_{EN})} = \left(\frac{\varphi}{1 - \varphi}\right) P^\phi$ by $\frac{P^T}{P^N}$ and then by $\frac{\rho^T}{\rho^N}$ with $\rho^j = \frac{W^j L^j}{P^j Y^j}$, denoting by $\gamma^T = (W^T L^T - \rho^T P^T NX)$ (with $\rho^T \equiv \frac{W^T L^T}{P^T Y^T}$) and $\gamma^N = W^N L^N$, and taking logarithm yields $\ln\left(\frac{\gamma^T}{\gamma^N}\right) = \eta + (\phi - 1) \ln P$ where η is a term composed of both preference (i.e., φ) and production (i.e., ρ^j) parameters, and the (logged) ratio of E^T (E^N) to $W^T L^T - \rho^T P^T NX$ ($W^N L^N$). We thus estimate ϕ by exploring alternatively the following empirical relationship:

$$\ln\left(\frac{\gamma^T}{\gamma^N}\right)_{i,t} = g_i + g_t + \eta_i t + \delta_i \ln P_{i,t} + \zeta_{i,t}, \quad (41)$$

where $\delta_i = (\phi_i - 1)$; g_i and g_t are the country fixed effects and time dummies, respectively; we add country-specific trends, as captured by $\eta_i t$, because η is composed of ratios that may display a trend over time.

Time series for sectoral value added at constant prices, labor compensation, and the relative price of non tradables are taken from EU KLEMS [2011] (see section A). Net exports correspond to the external balance of goods and services at current prices taken from OECD Economic Outlook Database. To construct time series for net exports at constant prices NX , data are deflated by the traded value added deflator of traded goods (i.e., P^T).

Since the LHS term of (40) and (41) and the relative price of non tradables as well display trends, we ran unit root and then cointegration tests. Having verified that these two assumptions are empirically supported, we estimate the cointegrating relationships by using DOLS and FMOLS estimators for cointegrated panel proposed by Pedroni [2000], [2001]. DOLS and FMOLS estimates are reported in Table 9, considering alternatively eq. (40) or eq. (41). Estimates of ϕ are reported in column 1 of Table 8 when calibrating the model for each country. As a reference model, we

Table 9: Estimates of the Elasticity of Substitution in Consumption between Tradables and Non Tradables (ϕ)

Country	$\hat{\phi}_i^{DOLS}$	$\hat{\phi}_i^{FMOLS}$	$\hat{\phi}_i^{DOLS}$	$\hat{\phi}_i^{FMOLS}$
	eq. (40)	eq. (40)	eq. (41)	eq. (41)
	(1)	(2)	(3)	(4)
AUS	0.081 (0.74)	0.295 ^a (3.09)	0.011 (0.08)	0.375 ^b (2.39)
AUT	0.574 (1.62)	1.019 ^a (2.99)	0.910 ^a (3.77)	1.414 ^a (4.98)
BEL	-0.268 (-1.58)	0.034 (0.17)	0.393 ^a (3.41)	0.749 ^a (4.60)
CAN	0.308 ^b (2.04)	0.439 ^a (3.75)	0.332 ^b (2.18)	0.569 ^a (4.94)
DEU	0.976 ^a (3.46)	1.126 ^a (2.99)	1.190 ^a (4.34)	1.363 ^a (3.47)
DNK	1.243 (1.24)	1.925 ^a (2.76)	1.698 ^b (2.35)	1.320 ^a (2.73)
ESP	0.527 ^a (3.31)	0.782 ^a (4.71)	0.177 (0.90)	0.355 ^c (1.71)
FIN	1.556 ^a (10.13)	1.043 ^a (9.30)	2.061 ^a (8.62)	1.412 ^a (8.45)
FRA	0.880 ^a (4.75)	0.896 ^a (6.29)	1.169 ^a (4.46)	1.048 ^a (5.58)
GBR	0.688 ^a (8.76)	0.477 ^a (9.57)	1.424 ^a (14.39)	1.183 ^a (15.03)
IRL	0.074 (0.28)	0.321 (1.48)	0.485 (0.89)	0.126 (0.28)
ITA	-0.365 ^a (-3.44)	-0.260 (-1.50)	-0.427 ^a (-3.04)	-0.206 (-1.17)
JPN	0.832 ^a (3.96)	0.713 ^a (3.25)	0.681 ^a (4.52)	0.655 ^a (4.55)
KOR	0.626 (0.52)	2.914 ^a (4.16)	1.006 (1.26)	2.237 ^a (4.60)
NLD	0.832 ^a (2.65)	0.644 ^c (1.93)	0.523 ^c (1.92)	0.412 (1.10)
NOR	1.138 ^a (7.26)	1.004 ^a (9.81)	2.080 ^a (14.42)	2.056 ^a (13.51)
SWE	0.364 ^b (2.24)	0.329 ^a (3.52)	1.073 ^a (5.85)	0.915 ^a (7.16)
USA	0.486 (1.37)	0.699 ^a (3.27)	0.571 (0.90)	0.804 ^b (2.07)
EU-12	0.590 ^a (9.65)	0.599 ^a (11.84)	0.890 ^a (26.17)	0.832 ^a (16.18)
Whole sample	0.586 ^a (11.63)	0.800 ^a (16.86)	0.853 ^a (24.52)	0.933 ^a (28.55)

Notes: Data coverage: 1970-2007 (except Japan: 1974-2007). All regressions include country fixed effects, time dummies and country specific trends. ^a, ^b and ^c denote significance at 1%, 5% and 10% levels. Heteroskedasticity and autocorrelation consistent t-statistics are reported in parentheses.

consider FMOLS estimates when exploring the empirical relationship (40); running regression (40) gives an estimate for the whole sample of 0.800 which is close to the value documented by Mendoza [1995] who reports an estimate of 0.74. As shown in Table 9, the estimated value of ϕ for Belgium is statistically significant only when exploring the empirical relationship (41) for this economy; in column 1 of Table 8, we set ϕ to 0.749 for Belgium. Because estimates for Italy are negative by using alternatively eq. (40) or eq. (41), the estimate of ϕ for this country is left blank in column 1 of Table 8 and ϕ is set to our panel data estimation for EU-12, i.e., 0.599, when calibrating the model for each country.

B.3 Labor Market Variables

We now describe the data employed to calibrate the model, focusing on labor market variables. To begin with, EU-10 refers to the following ten European countries: Austria, Belgium, Germany, Denmark, Spain, Finland, the United Kingdom, Ireland, Italy, Sweden; EU-12 includes EU-10 along with France and the Netherlands.

We construct the following labor market variables:

- **Sectoral unemployment rate** denoted by u^j ($j = T, N$) is the number of unemployed workers U^j in sector j as a share of the labor force $F^j \equiv L^j + U^j$ in this sector. LABORSTA database from ILO provides series for unemployed workers by economic activity for fifteen OECD countries out of eighteen in our sample. The longest available period ranges from 1987 to 2007. On average, our data covers 12.8 years per country. Series cover 18 sectors, according to ISIC Rev.3.1 classification. To construct L^j and U^j for $j = T, N$, we map the classifica-

tion used previously to compute series for sectoral wages, prices and real labor productivity indexes (see section A) into the 1-digit ISIC-rev.3 classification. The mapping was clear for all industries except for "Not classifiable by economic activity" (1-digit ISIC-Rev.3, code: X) when constructing L^j and U^j , and, "Unemployed seeking their first job" to identify U^j . These two categories have been split between tradables and non tradables according to the shares of total unemployment (excluding the two categories) between tradables and non tradables by year and country. In a few rare cases, the sum of sectoral employment provided by ILO did not correspond to total unemployment. These differences were usually due to missing data for some industries in the sectoral databases. In these cases, we added these differences in level, keeping however the share of each sector constant. In Table 10 we provide an overview of the classifications used to construct traded and non traded sectors variables. Once industries have been classified as traded or non traded, series for unemployed and employed workers are constructed by adding unemployed and employed workers of all sub-industries k in sector $j = T, N$ in the form $U^j = \sum_{k \in j} U_k$ and $L^j = \sum_{k \in j} L_k$. Data coverage: AUS (1995-2007), AUT (1994-2007), BEL (2001-2007), CAN (1987-2007), DEU (1995-2007), DNK (1994-1998 and 2002-2004), ESP (1992-2007), FIN (1995-2007), GBR (1988-2007), IRL (1986-1997), ITA (1993-2007), JPN (2003-2007), KOR (1992-2007), SWE (1995-2007) and USA (2003-2007). Data for unemployed workers by economic activity are not available for FRA, NLD and NOR.

- **Sectoral labor market tightness** denoted by θ^j ($j = T, N$) is calculated as the ratio of job vacancies in sector j (V^j) to the number of unemployed workers in that sector (U^j). To construct θ^j , we collect information on job vacancies and unemployed workers by economic activity. Sources for V^j : Job Openings and Labor Turnover Survey (JOLTS) provided by the Bureau of Labor Statistics (BLS) for USA, Eurostat database (NACE 1-digit) for a range of European Countries, Labour Market Statistics from the Office for National Statistics for the UK. Sources for U^j : Current Population Survey (CPS) published by the BLS for USA and LABORSTA (ILO) for European Countries.⁵⁷ As shown in Table 10, the level of detail in the definition of traded and non traded sectors differs across databases in two dimensions. First, the number of items to split disaggregated data varies across nomenclatures from a low eleven categories in the Eurostat database to a high of eighteen items in the LABORSTA database. Second, the definitions of items are not harmonized across the different sets of data. To generate sectoral variables in a consistent and uniform way, series on disaggregated data for vacancies and unemployed workers are added up to form traded and non traded sectors following, as close as possible, the classification we used for value added, hours worked and labor compensation. Once industries have been classified as traded or non traded, series for employment vacancies (unemployed workers resp.) are constructed by adding job openings (unemployed workers resp.) of all sub-industries k in sector $j = T, N$ in the form $V^j = \sum_{k \in j} V_k$ ($U^j = \sum_{k \in j} U_k$ resp.). Data coverage for V^j and U^j : AUT (2004-2005), DEU (2006-2007), FIN (2002-2007), GBR (2001-2007), SWE (2005-2007) and USA (2001-2007).
- **Aggregate labor market tightness** denoted by θ is also computed because series for θ^j are available over a too short time horizon and for a few countries only; θ is calculated as the ratio of job vacancies to registered unemployment. Source: Registered Unemployed and Job Vacancies Dataset, OECD. Coverage: AUS (1980-2007), BEL (1982-2003), DEU (1980-2007), ESP (1980-2004), FIN (1981-2007), GBR (1980-2007), NOR (1980-2007), SWE (1982-2007).
- **Job finding rate** denoted by m^j ($j = T, N$) is computed at a sectoral level by adopting the methodology proposed by Shimer [2012]. As Shimer [2012], we ignore movements in and out of the overall labor force. Since we compute the job finding rate for the traded and the non traded sector, we have to further assume that labor force is fixed at a sectoral level, i.e., we ignore reallocation of labor across sectors. More details on the model and the derivation of the results below can be found in the Technical Appendix. The monthly job finding rate $m^{j, < 1}(t)$ for sector j at time t is computed as follows:

$$m^{j, < 1}(t) = -\ln(1 - M^{j, < 1}(t)), \quad (42)$$

where t indexes months and the probability of finding a job $M^{j, < 1}$ within one month is given by

$$M^{j, < 1}(t) = 1 - \left[\frac{(1 - \alpha^{j, < 1}(t)) U^j(t)}{U^j(t-1)} \right], \quad (43)$$

with $\alpha^{j, < 1}(t) = \frac{U^{j, < 1}(t)}{U^j(t)}$ the share of unemployment less than one month ($U^{j, < 1}(t)$) among total monthly unemployment ($U^j(t)$) in sector j . Source: LABORSTA database from ILO for

⁵⁷The JOLTS and CPS databases provide (not seasonally adjusted) monthly data on vacancies and unemployed workers. We convert monthly data series into annual data series by summing the twelve monthly data points.

data on employment and unemployment at the sectoral level, and, OECD for unemployment by duration.

- **Job destruction rate** denoted by s^j ($j = T, N$) is estimated by solving this equation:

$$U^j(t) = \psi^j(t) \frac{s^j(t)}{s^j(t) + m^{j, <1}(t)} (U^j(t) + L^j(t)) + (1 - \psi^j(t)) U^j(t-1), \quad (44)$$

where ψ^j is the monthly rate of convergence to the long-run sectoral unemployment rate:

$$\psi^j(t) = 1 - e^{-(s^j(t) + m^{j, <1}(t))}. \quad (45)$$

When estimating s^j by using (44), the unemployment rate has not necessarily reached its long-run equilibrium. Since we calibrate the model so that the initial steady state is consistent with the empirical properties of each OECD economy, we have computed values for s^j which are consistent with the steady-state sectoral unemployment rate $u^j = \frac{s^j}{s^j + m^j}$ where u^j is the actual value taken from the data and m^j is computed by using (42). Reassuringly, average values for job destruction rates obtained from eq. (44) are close to those derived from the long-run equilibrium of the unemployment rate. More details can be found in the Technical Appendix.

- **Unemployment benefit net replacement rate** denoted by ϱ is shown in column 14 of Table 6 and is defined in section A. Replacement rates are averaged over 1980-2007 for all countries except Korea (2001-2007). Average EU-12 unemployment benefit replacement rate shown in Table 6 is the unweighted average of twelve EU members' replacement rates. Source: OECD, Benefits and Wages Database.
- **Firing cost** denoted by τ is shown in the last column of Table 6 is a measure of the strictness of legal protection against dismissals captured by the firing tax $x = \tau \cdot W$ in our model; it is calculated as the sum of the average advance notice and average severance payment after 4 and 20 years of employment. τ is expressed in monthly salary equivalents and is averaged over the period 1980-2005. Source: Fondazione de Benedetti.

Series of employment and unemployment by economic activity provided by ILO are not available for France, the Netherlands, Norway; while such data is available for Korea, unemployment by duration provided by the OECD is not available and thus prevents the estimation of the monthly job finding and job destruction rates. For these four countries, we proceeded as follows:

- **Monthly job finding rates** denoted by m come from Hobijn and Sahin [2009] who give average values for France (1975-2004), the Netherlands (1983-2004), Norway (1983-2004). For Korea, we average the job finding rates taken from Chang et al. [2004] over 1993-1994.
- **Unemployment rate** denoted by u is the number of unemployed people as a percentage of the labor force. Coverage: FRA (1975-2004), the NLD (1983-2004), NOR (1983-2004). Source: OECD, LFS database.
- **Monthly job separation rate** denoted by s is computed so as to be consistent with the steady-state unemployment rate given by $u = \frac{s}{s+m}$.

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Table 10: Sectoral Classifications for Labor Market Variables

Sector	EU KLEMS/STAN	LABORSTA Employment	LABORSTA Unemployment	JOLTS (BLS)	CPS (BLS)	EUROSTAT
Tradables	Agriculture, Hunting, Forestry and Fishing (A-B) Mining and Quarrying (C) Total Manufacturing (D) Transport and Storage and Communication (I) Financial Intermediation (J) Electricity, Gas and Water Supply (E) Construction (F) Wholesale and Retail Trade (G)	Agriculture, Hunting, Forestry and Fishing (A-B) Mining and Quarrying (C) Manufacturing (D) Transport, Storage and Communications (I) Financial Intermediation (J) Electricity, Gas and Water Supply (E) Construction (F) Wholesale and Retail Trade (G)	Agriculture, Hunting, Forestry (A) Fishing (B) Mining and Quarrying (C) Manufacturing (D) Transport, Storage and Communications (I) Financial Intermediation (J) Unemployed seeking their first job Electricity, Gas and Water Supply (E) Construction (F) Wholesale and Retail Trade (G)	Mining and logging Manufacturing Transportation and utilities Information Finance and insurance	Agriculture Mining and quarrying Manufacturing Transportation and utilities Information Financial activities	Agriculture and fishing Mining and quarrying Manufacturing Transport, storage and communication Financial intermediation
Non Tradables	Hotels and Restaurants (H) Real Estate, Renting and Business Activities (K) Community Social and Personal Services (LtQ)	Hotels and Restaurants (H) Real Estate, Renting and Business Activities (K) Public Adm., Defence and Compulsory Social Security (L) Education (M) Health and Social Work (N) Other Community, Social and Personal Service Activities (O) Households with Employed Persons (P) Extra-Territorial Organizations and Bodies (Q) Not classifiable by economic activity (X)	Hotels and Restaurants (H) Real Estate, Renting and Business Activities (K) Public Adm., Defence and Compulsory Social Security (L) Education (M) Health and Social Work (N) Other Community, Social and Personal Service Activities (O) Households with Employed Persons (P) Extra-Territorial Organizations and Bodies (Q) Not classifiable by economic activity (X) Unemployed seeking their first job	Construction Wholesale trade Retail trade Real estate and rental Business services Government Education and health Leisure and hospitality	Construction Wholesale and retail trade Business services Government workers Education and health services Leisure and hospitality	Electricity, gas and water supply Construction Wholesale and retail trade Hotels and restaurants Real estate, renting and business activities Public adm. and community services
Unclassified				Other services	Other services	
						Self-employed, unincorporated and unpaid family workers