Exchange Rate Regimes and Wage Comovements in a Ricardian Model with Money*

Yoshinori Kurokawa, Jiaren Pang, and Yao Tang†

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Abstract

We construct a Ricardian model of trade with money and trade costs. The model predicts that the nominal wages of the trading countries exhibit stronger positive comovements when the countries fix their bilateral exchange rates, while comovements of real wages are not affected by exchange rate regimes. Our numerical experiments suggest that a reduction in trade costs increases both nominal and real wage comovements, regardless of regimes. When downward nominal wage rigidity is introduced, nominal wage comovements under the fixed regime remain stronger than under the flexible regime and the difference is smaller on the shorter time horizon, while a slight difference in real wage comovements between the two regimes shows up and is larger on the shorter time horizon. When we consider membership in the Economic and Monetary Union of the European Union as a fixed exchange rate regime, panel regression results based on data from OECD countries are broadly consistent with our model and numerical experiments.

JEL classification: F16, F31, F45
Keywords: Ricardian model, fixed exchange rate regime, currency union, trade, wage comovements

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†Kurokawa: Faculty of Humanities and Social Sciences, University of Tsukuba, 1-1-1 Tennodai, Tsukuba, Ibaraki 305-8571, Japan; E-mail: kurokawa.yoshi.fw@u.tsukuba.ac.jp. Pang: Department of Finance, School of Economics and Management, Tsinghua University, Beijing 100084, China; E-mail: pangjr@sem.tsinghua.edu.cn. Tang: Corresponding author; Department of Economics, Bowdoin College, 9700 College Station, Brunswick, Maine 04011-8497, USA; E-mail: ytang@bowdoin.edu.

1 Introduction

Prices in a country tend to comove positively with prices in its trading partner to which it pegs its currency (e.g., Edwards, 1993; Calvo and Vegh, 1994; Willett, 1998). In addition, price levels and wage levels are strongly and positively correlated across countries (e.g., Crucini and Yilmazkuday, 2014), which indicates that wages can be approximately representative of prices. These two observations suggest that under a fixed exchange rate regime, nominal wages should comove positively between trading countries. This possibility is important particularly for countries that peg their currency or join a currency union because their wages can be tightly linked to wages in their trading partners. In fact, McKinnon (2005, 2006) argues that it is nominal wage changes that would be the main vehicle of international adjustment under a fixed exchange rate.

Few studies, however, have theoretically or empirically investigated comovements of nominal wages. This is probably because typical trade models are real models and thus do not explicitly address the monetary aspects of trade, although Dornbusch, Fischer and Samuelson (1977) and Ito and Ohyama (1985) note that it is possible to extend the discussion of the standard Ricardian model of trade to analyze nominal variables. This paper now fills this void by developing a Ricardian model with money and trade costs and using it to guide our empirical analysis on the relationship between exchange rate regimes and wage comovements.

Our production structure extends the Ricardian model with a continuum of goods developed by Dornbusch et al. (1977) to a stochastic model. We are similar to Eaton and Kortum (2002) in that we extend the model of Dornbusch et al. (1977), but we differ from them in that the productivity distribution is stochastic over time in our model while it is not in Eaton and Kortum (2002). Our preference structure is novel in the Ricardian model literature in that our utility function is a money-in-the-utility function. The asset structure of our model follows Chari, Kehoe and McGrattan (2002).

We then use our model to analyze how exchange rate regimes affect nominal wage comovements between the trading countries, measured by nominal wage correlations. The main prediction is that nominal wages comove strongly and positively between trading countries that peg their currencies. This has implications for exchange rate policies. Under a fixed exchange rate regime, wage inflation in a foreign country can be accompanied by wage inflation in a home country. Under a flexible exchange rate regime, on the other hand, changes of exchange rates can shut out the repercussions of changes of nominal wages in a foreign country through trade.

We also conduct two numerical experiments that extend the baseline model. The first experiment varies trade costs to test if trade intensity matters for the comovements. We find that through an increase in trade intensity, a reduction in trade costs increases nominal wage comevements under both the fixed and flexible exchange rate regimes. The second experiment introduces downward nominal wage rigidity to guide and interpret regressions in the short run vs. the long run. We find that the comovements between home and foreign nominal wages decline under both regimes when rigidity is introduced. Meanwhile, nominal wage comovements under the fixed regime remain stronger than under the flexible regime and the difference between the two regimes is smaller on the shorter time horizon.

Immediately, a natural question is whether our findings about nominal wage comovements can be extended to real wage comovements. This is important particularly for households because their real purchasing power of earnings can be tightly linked to that in the trading partners. In our baseline model in which money is neutral, it is not surprising that exchange rate regimes do not interfere with real wage comovements. Meanwhile, our numerical analysis shows that a reduction in trade costs tends to increase real wage comovements under both the fixed and flexible exchange rate regimes. When we introduce downward nominal wage rigidity to break money neutrality, comovements in real wages decline slightly under both regimes, while a small difference in real wage comovements between the two regimes shows up and is larger on the shorter time horizon.

The theoretical results regarding the effects of (1) exchange rate remiges, (2) trade costs, and (3) nominal wage rigidity provide direct guidance to the following empirical questions: Do nominal and real wage comovements differ (1) under the fixed regime vs. the flexible regime, (2) with different levels of trade intensity, and (3) in the short-run vs. the long-run? To examine these questions, we collect panel data of 33 OECD countries from 1971 to 2012, and perform empirical analysis at one-year and four-year frequencies under the premise that nominal wage rigidity is more likely at the one-year frequency.

The regression results suggest that if a country and its main trade partner were in the Economic and Monetary Union (EMU) of the European Union, then their nominal wages experienced significantly stronger comovements. The positive effects of the EMU on comovements are smaller in the short run than in the long run, although the difference is statistically insignificant. When we restrict the sample to EMU countries, we find some evidence that these countries experienced stronger positive nominal wage comovements compared to the pre-euro era. For the non-EMU countries, there is no evidence that non-currency-union pegs strengthened nominal wage comovements. Turning to real wage comovements, country pairs with EMU membership had a more positive effect on real wage comovements in the short run than in the long run, although the effects were insignificant. Lastly, the trade intensity between two countries is positively correlated with the comovements of both nominal and real wages. These findings are broadly consistent with our model and numerical analysis.

Our paper thus makes the following contributions. First, it adds to the literature on exchange rates and wages. While many studies analyze the relationship between real exchange rates and real wages (e.g., Goldberg and Tracy 2000; Campa and Goldberg 2001), our paper examines the relationship between nominal exchange rates and both nominal and real wages. In particular, our paper reveals that the effects of trade on the nominal wage comovements between the trading countries are different under the fixed and flexible exchange rate regimes. To the best of our knowledge, our paper is the first to use a Ricardian model to analyze the relationship between exchange rates and wage comovements.

Second, our paper adds to the empirical evidence of nominal wage comovements.

There are three papers that also examine this subject and are closely related to our work. The first, Budd, Konings and Slaughter (2005), highlights the comovements of nominal wages within a multinational firm through internal risk sharing. The second, Robertson (2000), highlights the comovements of nominal wages, resulting from emigration, between the border region of Mexico and the U.S. and between the interior and border regions in Mexico. The third, Lamo, Perez and Schuknecht (2008), highlights the comovements of public and private sector nominal wages over business cycles since the 1960s in the euro area and a number of other OECD countries.[1] While these previous works focus on inter- and intra-country nominal wage comovements due to internal risk sharing within a multinational firm and emigration, we establish that trade and exchange rate regimes provide an alternative cause of nominal wage comovements.

Third, our paper adds to the literature on comovements of exchange rates and macroeconomic real variables. For example, Stockman (1987), Flood and Rose (1995), Obstfeld and Rogoff (1995a), Stockman (1998), Kollmann (2001), and Duarte, Restuccia and Waddle (2007) have analyzed comovements between nominal/real exchange rates and real variables such as output, but have not analyzed those between the domestic and foreign real variables. Baxter and Stockman (1989) and Chari et al. (2002) have analyzed both types of comovements, and the former study has also examined an effect of exchange rate regimes. In this line of studies, our paper is the closest to Baxter and Stockman (1989) in that both examine an effect of exchange rate regimes on comovements between the domestic and foreign real variables. However, our paper mainly studies comovements of real wages while they study comovements of output and government consumption. Additionally, our paper examines effects of trade intensity and nominal wage rigidity as well.

Fourth, our paper adds to the literature on the relationship between real exchange rates and the relative price of nontradable goods (e.g., Betts and Kehoe 2006, 2008). While

[1]Lamo et al. (2008) also study causal linkages between public and private sector wages, i.e., the public/private wage leadership. Their causality analysis suggests that although influences from the private sector appear on the whole to be stronger, there are direct and indirect feedback effects from a public wage setting in a number of countries as well. See the references in their paper for studies on wage leadership in a particular country (primarily Sweden and several others).

past studies have derived this relationship from traditional real exchange rate theory, our paper derives it from a Ricardian model of trade with money and thus provides it with an alternative theoretical foundation.

The rest of this paper is organized as follows. In Section 2, we construct a Ricardian model with money and trade costs and derive the predictions on wage comovements. We present supporting empirical evidence in Section 3. Section 4 concludes by offering a brief discussion of the results.

2 Theory

In this section, we construct a Ricardian model of trade with money and trade costs and thus address the monetary aspects of trade. As mentioned in the introduction, the setup of the model borrows from two main sources, first, the Ricardian models (Dornbusch et al., 1977; Eaton and Kortum, 2002), and second, models of money and exchange rates (Chari et al., 2002). The model in our paper is highly stylized, but it allows us to obtain clear insights about the effects of exchange rate regimes and trade on wage comovements.

2.1 Model setup

There are two countries, home and foreign. The variables associated with the home and foreign countries are indicated by superscripts H and F, respectively. Each country is capable of producing the same continuum of tradable goods. The goods are indexed by $i \in [0, 1]$. There exist iceberg trade costs $\tau \geq 0$, i.e., when a country ships $1 + \tau$ unit of goods to the other country, only 1 unit arrives. Because of trade costs, some tradable varieties may not be traded in equilibrium. Each country also produces a nontradable good, z. As in typical Ricardian models, there is only one input factor, labor, and it is perfectly mobile across industries within a country but immobile across countries.[2] Thus, wages are the same across industries within a country but can be different across countries.

[2]Because our focus is on labor, similar to Eaton and Kortum (2002), our model does not include capital, maintaining the model in a simple form. In Section 3.1, however, we will discuss migration and capital movements and include their controls in our regressions.

The asset structure follows that of Chari et al. (2002). In each period t, the two-country world economy experiences one of finitely many states, s_t. The history of states up through period t is denoted by $s^t = (s_0, s_1, ..., s_t)$. The initial realization of s_0 is given. In this economy, there are complete, state-contingent, and one-period bonds denominated in the *home* currency, and both home and foreign consumers can buy and sell these bonds.[3]

For country $j = H, F$, the period preference of the infinitely lived representative consumer is

$$U_t^j = \frac{\left(C_t^j\right)^{1-\zeta}}{1-\zeta} - \kappa \frac{\left(L_t^j\right)^{1+\gamma}}{1+\gamma} + \chi h\left(\frac{M_t^j}{P_t^j}\right),$$

where

$$C_t^j = \left[\left(\int_0^1 C_t^j(i)^{\frac{\eta-1}{\eta}} di\right)^{\frac{\eta}{\eta-1}\cdot\epsilon} \cdot C_t^j(z)^{1-\epsilon}\right],$$

$\zeta, \kappa, \gamma, \chi$ and $\eta > 0$ and $0 < \epsilon < 1$. To conserve space, we use the subscript t to indicate that a variable is in s^t. For example, U_t^j stands for $U^j(s^t)$, the utility in s^t. Here, $C_t^j(i)$ denotes the consumption of tradable good i in country j, and $C_t^j(z)$ is the consumption of the nontradable good in country j. The parameter η governs the elasticity of substitution between tradable goods, and ϵ is the fraction of expenditure that goes to the tradable goods. The quantity L_t^j is labor supply. The variables M_t^j and P_t^j are money supply and the aggregate price level.

[3] Including bonds denominated in the foreign currency would be redundant as this does not add to the structure of the bond market.

The period budget constraint in each country is

$$\int_0^1 P_{Ht}(i)\, C_t^H(i)\, di + P_t^H(z)\, C_t^H(z) + M_t^H + \sum_{s_{t+1}} q_{t+1|t}^H B_{t+1}^H$$
$$= W_t^H L_t^H + M_{t-1}^H + B_t^H + \Pi_t^H + T_t^H,$$
$$\int_0^1 P_{Ft}(i)\, C_t^F(i)\, di + P_t^F(z)\, C_t^F(z) + M_t^F + \sum_{s_{t+1}} q_{t+1|t}^H B_{t+1}^F / e_t$$
$$= W_t^F L_t^F + M_{t-1}^F + B_t^F / e_t + \Pi_t^F + T_t^F.$$

There is also a borrowing constraint in each country

$$B_{t+1}^H \geq -P_t^H \bar{b}^H,$$
$$B_{t+1}^F / e_t \geq -P_t^F \bar{b}^F.$$

The variables $P_{jt}(i)$, $P_t^j(z)$, and W_t^j are the nominal price of tradable good i, the nominal price of nontradable good, and nominal wages, all denoted in the local currency.[4] B_{t+1}^j is the quantity of the nominal bond bought in period t and state s^t with payoffs contingent on some particular state s_{t+1} at $t+1$; one unit of this bond pays one unit of the *home* currency in period $t+1$ if the particular state s_{t+1} occurs and 0 otherwise. $q_{t+1|t}^H$ is this bond's price in the *home* currency, and $q_{t+1|t}^H = q_{t+1}^H / q_t^H$ clearly. e_t is the nominal exchange rate, defined as the price of foreign currency in the home currency. Π_t^j and T_t^j are profits of firms and a nominal transfer from the government of country j. The positive constant $\bar{b}^j$ is the constraint on real borrowing. Our budget constraint is similar to that in the Chari et al. (2002) model, except that ours has the consumption of nontradable goods.

Given the prices $P_{jt}(i)$ and $P_t^j(z)$, the minimization of the cost of C_t^j yields the following unit cost of C_t^j, which we refer to as the price of C_t^j

$$P_t^j = \left[\epsilon^{-\epsilon}(1-\epsilon)^{\epsilon-1}\right]\left[\int_0^1 (P_{jt}(i))^{1-\eta}\, di\right]^{\frac{1}{1-\eta}\epsilon} \left(P_t^j(z)\right)^{1-\epsilon}.$$

[4] A tradable good i that the consumer buys can be a home or foreign good, so there is no superscript j for the variable $P_{jt}(i)$. Instead, we use the subscript j to indicate that it is the price that the consumer in country j actually pays.

Hence, the budget constraint in each country can be written as

$$P_t^H C_t^H + M_t^H + \sum_{s_{t+1}} q_{t+1|t}^H B_{t+1}^H = W_t^H L_t^H + M_{t-1}^H + B_t^H + \Pi_t^H + T_t^H,$$
$$P_t^F C_t^F + M_t^F + \sum_{s_{t+1}} q_{t+1|t}^H B_{t+1}^F / e_t = W_t^F L_t^F + M_{t-1}^F + B_t^F / e_t + \Pi_t^F + T_t^F.$$

The production technology for tradable and nontradable goods is

$$Y_t^j (i) = A_t^j (i) L_t^j (i),$$
$$Y_t^j (z) = A_t^j (z) L_t^j (z),$$

where $A_t^j (i)$ and $A_t^j (z)$ are the stochastic productivities. Here, we do not specify their stochastic processes because it is not necessary for the derivations of Propositions 1 and 2 in Section 2.2. In Section 2.3, we will specify them for further analysis.

The market for each tradable good is perfectly competitive. The home producers of good i have to compete with foreign producers of the same good. Home and foreign consumers only buy from the producers with the lowest price. Consequently, the domestic prices posted by the home and foreign firms for good i in their respective local currencies are

$$P_t^H (i) = W_t^H / A_t^H (i),$$
$$P_t^F (i) = W_t^F / A_t^F (i),$$

respectively, but the prevailing market prices that consumers in the home and foreign countries actually pay are now given by

$$P_{Ht} (i) = min \left\{ P_t^H (i), (1+\tau) P_t^F (i) e_t \right\},$$
$$P_{Ft} (i) = min \left\{ (1+\tau) P_t^H (i) / e_t, P_t^F (i) \right\}.$$

As in Dornbusch et al. (1977), we assume that $A_t^H (i) / A_t^F (i)$ is strictly decreasing in

i. Then it follows that $P_t^H(i)/P_t^F(i)$ is strictly increasing in i. Thus, there exists a cutoff variety k_t^F such that for all $i \in [0, k_t^F)$, $P_t^H(i) < (1+\tau) P_t^F(i) e_t$ holds. Similar, there exists a cutoff variety $k_t^H < k_t^F$ such that for all $i \in (k_t^H, 1]$, $(1+\tau) P_t^H(i)/e_t > P_t^F(i)$ holds. Therefore, varieties in $[0, k_t^H)$ are produced only by the home country, while varieties in $(k_t^F, 1]$ are produced only by the foreign country. The varieties $i \in [k_t^H, k_t^F]$ are not traded due to the trade costs and are produced in both countries.

The market for nontradable goods is also perfectly competitive. Consequently, the local-currency prices for the nontradable goods are

$$P_t^j(z) = W_t^j / A_t^j(z).$$

As in Chari et al. (2002), money is introduced into the utility function. The money supplies in the two countries follow stochastic processes, to be specified in Section 2.2 for different exchange rate regimes. In country $j = H, F$, any new money balance $M_t^j - M_{t-1}^j$ is distributed to households through lump-sum transfer. That is, $T_t^j = M_t^j - M_{t-1}^j$. As in Chari et al. (2002), the equilibrium exchange rate is determined in the asset (bond) market and is given by the following first order condition

$$e_t = \frac{P_t^H \left(C_t^H\right)^\zeta}{P_t^F \left(C_t^F\right)^\zeta} \delta = \frac{\lambda_t^F}{\lambda_t^H} \delta, \tag{1}$$

where δ is a constant depending on the state of the economy in the initial period, and is the marginal utility of consumption per the home currency in the home country relative to that in the foreign country in the initial period. The variables λ_t^H and λ_t^F are the marginal utility associated with the home and foreign nominal wealth, respectively. Unlike Chari et al. (2002), our focus is not on nominal price rigidity. Hence, we assume flexible prices.

The market clearing conditions are

$$
\begin{aligned}
L_t^H &= \int_0^{k_t^F} L_t^H(i)\,di + L_t^H(z), \\
L_t^F &= \int_{k_t^H}^1 L_t^F(i)\,di + L_t^F(z), \\
Y_t^H(i) &= C_t^H(i) + C_t^F(i)(1+\tau) \quad \forall\, i < k_t^H, \\
Y_t^F(i) &= C_t^H(i)(1+\tau) + C_t^F(i) \quad \forall\, i > k_t^F, \\
Y_t^j(i) &= C_t^j(i) \quad \forall\, k_t^H \le i \le k_t^F, \\
Y_t^j(z) &= C_t^j(z), \\
B_t^H + B_t^F &= 0.
\end{aligned}
$$

At the beginning of each period, both monetary shocks and productivity shocks, which will be introduced in Sections 2.2 and 2.3, are observed by all players in the economy. Firms then post prices, consumers make purchase decisions, production occurs, and markets clear. Because our main interests are in the role of exchange rate regimes in anchoring nominal wages in the long run, for most of the paper we assume that all prices and wages are flexible, which indicates that nominal variables do not affect real variables. In the numerical experiments in Sections 2.3 and 2.4, we change this assumption and explore a version of the model with flexible prices but downward-rigid nominal wages.

2.2 Exchange rate regimes and the nominal wage comovements

First, we characterize the general relationship between the changes in home and foreign nominal wages in Proposition 1. We briefly outline the derivations here and leave the proof to the Supplementary Appendix. Using the relationship between nominal prices and nominal wages implied by the technology and market structure, we can express the real exchange rate as a function of the nominal exchange rate, nominal wages, productivities, and prices:

$$e_t \frac{P_t^F}{P_t^H} = \left(\frac{e_t W_t^F}{W_t^H} \right)^{1-\epsilon} \left(\frac{A_t^H (z)}{A_t^F (z)} \right)^{1-\epsilon} D_t, \tag{2}$$

where

$$D_t = \left[\frac{\int_0^{k_t^H} \left((1+\tau) P_t^H (i) \right)^{1-\eta} di + \int_{k_t^H}^{k_t^F} \left(P_t^F (i)\, e_t \right)^{1-\eta} di + \int_{k_t^F}^{1} \left(P_t^F (i)\, e_t \right)^{1-\eta} di}{\int_0^{k_t^H} \left(P_t^H (i) \right)^{1-\eta} di + \int_{k_t^H}^{k_t^F} \left(P_t^H (i) \right)^{1-\eta} di + \int_{k_t^F}^{1} \left((1+\tau) P_t^F (i)\, e_t \right)^{1-\eta} di} \right]^{\frac{1}{1-\eta}\epsilon}.$$

The term D_t can be viewed as the ratio of the price index for tradable goods in the foreign country to that in the home country. The presence of the term D_t is due to the trade costs τ. When τ is zero, $D_t = 1$.[5]

From equation (2), we now obtain Proposition 1 that characterizes the general relationship between home and foreign wage growth.

Proposition 1. *The relationship between growth in home nominal wages and the foreign counterpart is*

$$\frac{W_t^H}{W_{t-1}^H} = \frac{W_t^F}{W_{t-1}^F} \left(\frac{e_t}{e_{t-1}} \right)^{\frac{\epsilon}{\epsilon-1}} \left(\frac{D_t}{D_{t-1}} \right)^{\frac{1}{1-\epsilon}} \left(\frac{P_t^H}{P_{t-1}^H} \frac{P_{t-1}^F}{P_t^F} \right)^{\frac{1}{1-\epsilon}} \frac{A_t^H (z)}{A_{t-1}^H (z)} \frac{A_{t-1}^F (z)}{A_t^F (z)}. \tag{3}$$

Based on Proposition 1, we can decompose the change in home nominal wages into changes in foreign nominal wages, nominal exchange rates, the relative price of tradable goods, home and foreign aggregate prices, and productivities of home and foreign producers of the nontradable good. Intuitively, if the nominal exchange rate is flexible, it is less likely that the change in home nominal wages must match the foreign counterpart. Hence, we expect comovements of nominal wages to be stronger under the fixed exchange rate regime.

Next, we further specify our model by making explicit assumptions about the utility of the real balance and the stochastic processes governing money supplies, which are required to establish Proposition 2. Specifically, for country $j = H, F$, we make the

[5]Depending on the distribution of tradable productivities in the two countries, the relationship between D_t and τ can be complex. For instance, for positive values of τ, if distributions of tradable productivities in the two countries are mirror images to each other (i.e., $A_t^H (i) = A_t^F (1-i)$ for all i), then D_t is also 1.

following assumptions:

- (a) The utility of the real balance is $h\left(M_t^j/P_t^j\right) = ln\left(M_t^j/P_t^j\right)$.

- (b1) When the exchange rate is flexible, the money supply of country j follows the stochastic process

$$M_t^j = exp\left(\mu_t^j\right) M_{t-1}^j \left(1 + g^j\right),$$

  where g^j is a constant, and μ_t^H and μ_t^F are zero-mean *i.i.d.* shocks with a common cdf $\Phi(\mu)$.

- (b2) When the exchange rate is fixed, the foreign money supply follows the stochastic process

$$M_t^F = exp\left(\mu_t^F\right) M_{t-1}^F \left(1 + g^F\right),$$

  where g^F is a constant, and μ_t^F is a zero-mean *i.i.d.* shock with the cdf $\Phi(\mu)$. The home country sets M_t^H to fix the exchange rate.

- (c) Both monetary shocks are independent of the productivity processes.[6]

Based on the assumptions, the first order conditions with respect to labor supply and the expression for exchange rates, we can write the expression for the nominal wage growth rate of the home country under the flexible exchange rate regime as

$$ln\left(\frac{W_t^H}{W_{t-1}^H}\right) = ln(1 + g^H) + \mu_t^H + \gamma ln\left(\frac{L_t^H}{L_{t-1}^H}\right).$$

[6] This assumption is common in the literature on macroeconomics, especially international macroeconomics (Hairault and Portier, 1993; Chari et al., 2002; Devereux and Sutherland, 2007). In the spirit of Friedman and Schwartz (1963) and Romer and Romer (1989), we regard monetary shocks as nominal disturbances independent of the real side of the economy and the policy response of the central banks to the real economy. Therefore, we believe that it is reasonable to assume independence between the monetary shocks and the productivity processes.

Under the fixed regime, the nominal wage growth rate of the home country is

$$ln\left(\frac{W_t^H}{W_{t-1}^H}\right) = ln(1+g^F) + \mu_t^F + \gamma ln\left(\frac{L_t^H}{L_{t-1}^H}\right).$$

Similarly, we can write the nominal wage growth rate of the foreign country under both regimes as

$$ln\left(\frac{W_t^F}{W_{t-1}^F}\right) = ln(1+g^F) + \mu_t^F + \gamma ln\left(\frac{L_t^F}{L_{t-1}^F}\right).$$

From the last three equations, it is obvious that when the exchange rate regime is fixed, the comovements between home and foreign wages are caused by both the identical monetary effects, $ln\left(1+g^F\right) + \mu_t^F$, and the correlation in labor supply changes. Under the flexible exchange rate regime, the monetary effects in the two countries are not correlated unless the monetary shocks are correlated. In this case, the comovements in wages will be weaker because the comovements are caused by only the correlation in labor supply changes.

We now formalize these results regarding nominal wage comovements under different exchange rate regimes as Proposition 2, and leave the proof to the Supplementary Appendix.

Proposition 2. *Under assumptions (a) and (c), nominal wage comovements between the countries are more positive or less negative under the fixed exchange rate regime (assumption (b2)), compared to the flexible exchange rate regime (assumption (b1)). To be specific,*

$$corr^{FX}\left(ln\left(\frac{W_t^H}{W_{t-1}^H}\right), ln\left(\frac{W_t^F}{W_{t-1}^F}\right)\right) - corr^{FL}\left(ln\left(\frac{W_t^H}{W_{t-1}^H}\right), ln\left(\frac{W_t^F}{W_{t-1}^F}\right)\right) \geq 0,$$

where FX and FL denote the fixed and flexible exchange rate regimes, respectively. The strict equality holds only when monetary shocks μ_t^H and μ_t^F are perfectly correlated.

2.3 The effects of trade costs and downward nominal wage rigidity on nominal wage comovements

In this section, we examine how two additional factors, trade costs and downward nominal wage rigidity, may affect nominal wage comovements under each of the exchange rate regimes. Given that we use the Ricardian model of trade to analyze the relationship between exchange rate regimes and wage comovements, it is important to examine whether trade intensity affects our main findings. Thus we vary trade costs to see if trade intensity matters for the comovements. Intuitively, if trade costs are reduced, more tradable goods will become traded, potentially leading to stronger alignment of nominal wages. Downward nominal wage rigidity is also important because it is deemed a salient feature of the labor markets in the Eurozone (Schmitt-Grohé and Uribe, 2013) and may make nominal wage comovements weaker, particularly on the shorter time horizon when downward rigidity is more likely to be present. Thus we introduce downward nominal wage rigidity and compare the results on the shorter and longer time horizons to guide and interpret our regressions in the short run vs. the long run in Section 3.

As it is difficult to obtain analytic results related to trade costs and downward nominal wage rigidity in our model, we resort to numerical experiments. Similar to Proposition 2, we measure wage comovements as the correlation coefficient between wage growth rates. First, without introducing nominal wage rigidity, we calculate the correlation coefficient between nominal wage growth rates under both flexible and fixed exchange rate regimes for different values of the trade costs τ. We then repeat the calculations for a setup with flexible nominal prices and downward-rigid nominal wages.

The values of key parameters are obtained from the literature. To be precise, the constant relative risk aversion parameter (ζ) is 3 (Hubbard, Skinner and Zeldes, 1994), the disutility of labor parameter (γ) is 0.262 (Imai and Keane, 2004), the share of all tradable goods in total expenditures (ϵ) is 0.3 (Arkolakis and Ramanarayanan, 2009), the elasticity of substitution between tradable goods (η) is 1.5 (Backus, Kehoe and Kydland, 1994), and the upper bound of trade costs τ is 0.6 (Xu, 2003).

We now specify the productivity processes. For country $j = H, F$, we make the following assumption:

- (d) The productivities for tradable and nontradable goods are

$$A_t^j(i) = A^j(i)\, exp\left(a_t^j + \alpha_t^j\right),$$
$$A_t^j(z) = A^j(z)\, exp\left(a_t^j(z) + \alpha_t^j(z)\right),$$

  where a_t^j and $a_t^j(z)$ are the deterministic trends of the productivities, and α_t^j and $\alpha_t^j(z)$ are the stochastic components. The stochastic components follow AR(1) processes

$$\alpha_t^j = \rho^j \alpha_{t-1}^j + u_t^j,$$
$$\alpha_t^j(z) = \rho^j(z)\, \alpha_{t-1}^j(z) + v_t^j,$$

  where u_t^j and v_t^j are zero-mean shocks and they can be correlated.

Following Kehoe and Perri (2002), we assign a value of 0.95 to the persistence of tradable and nontradable productivity shocks in both countries (ρ^j and $\rho^j(z)$). As in Stockman and Tesar (1995), the covariance matrix of productivity shocks is specified as

$$V\left(\left[u_t^H \quad v_t^H \quad u_t^F \quad v_t^F\right]'\right) = \frac{1}{100}\begin{pmatrix} 3.62 & 1.23 & 1.21 & 0.51 \\ 1.23 & 1.99 & 0.51 & 0.27 \\ 1.21 & 0.51 & 3.62 & 1.23 \\ 0.51 & 0.27 & 1.23 & 1.99 \end{pmatrix}.$$

We follow Chari et al. (2002) to set the size of home and foreign monetary shocks to be 0.023. We assume that the monetary shocks are independent of each other. Consistent with assumption (c), the monetary shocks are also independent of productivity shocks.

To study the effects of downward nominal wage rigidity, it is important to have frequent drops in nominal wages in the flexible wage equilibrium. We set the growth rate of money supplies in both countries (g^H and g^F) to be 0.02 such that nominal wages would drop in about half of the numerical experiments. To reduce computational time and improve numerical stability, we specify the baseline productivity for tradable goods as $A^H(i) = 2 - i$ and $A^F(i) = 1 + i$. We set the deterministic trend growth in both tradable good productivity and nontradable good productivity to be 0.021, the average growth rate of labor productivity in the sample countries for our empirical analysis in Section 3. Other productivity parameters are normalized to 1 because they affect the levels but not the growth rates of nominal wages.

We also need to deal with trade deficits because our model does not impose a balanced trade condition so that international borrowing and lending are possible. As trade deficits are not determined endogenously in our model, we follow the approach of Dekle, Eaton and Kortum (2007, 2008) and take trade deficits from the data, as do di Giovanni, Levchenko and Zhang (2014) in the unbalanced-trade version of their model. To be specific, the mean trade deficits are -0.7% of the GDP, which is the average level of current account deficits of countries in our sample. We further assume that trade deficits follow an AR(1) process with a persistence parameter of 0.7 and shocks to trade deficits have a standard deviation of 2.23%. These two values are obtained from running AR(1) regressions of the current account deficits for each country in our sample, and taking the average of the relevant estimates across countries.

We vary τ between 0 and 0.6 and the step size is 0.01. For each value of τ, we draw 50 sets of productivity and monetary shocks, and compute the correlation between nominal wage growth rates using the 50 pairs of calculated nominal wage growth rates in the two countries. Repeating this process 100,000 times, we obtain 100,000 correlation coefficients for each value of τ. Lastly, we compute the average correlation coefficient for each τ and plot the average against τ.

It should be noted that the purpose of our numerical experiments is to study the qualitative effects of trade costs and downward-rigid nominal wages; we do not seek to match any moments or statistics of the data.

First, for the case of no nominal wage rigidity, we plot the correlations between the home and foreign nominal wage growth rates for different values of trade costs τ in Figure 1. As we can see, a reduction in trade costs τ tends to increase the correlation between the home and foreign nominal wage growth rates under both the fixed and flexible exchange rate regimes. This implies a negative relationship between trade costs and nominal wage comovements regardless of the regime. Intuitively, when more trade is enabled by a decrease in trade costs, nominal wages in the two countries are more closely linked.

Next, we introduce downward nominal wage rigidity, a feature that is not included in the above theoretical model. For each draw of shocks, we compute the equilibrium with flexible nominal prices and wages. If this flexible-wage equilibrium requires a decrease in nominal wage(s), we follow Benigno and Ricci (2011) and impose that the nominal wage(s) is equal to wage(s) in the last period and recalculate the equilibrium. To guide and interpret our empirical analysis in Section 3 that uses data on both shorter and longer time horizons, we compute the comovements of downward-rigid nominal wages over one period and four periods. The results of these two numerical experiments are plotted in Figures 2 and 3. Comparing Figure 2 to Figure 1, we can see that the wage rigidity reduces the correlations between nominal wage growth rates under both the flexible and fixed exchange rate regimes.

To see how different the effect of fixed exchange rate regimes on nominal wage comovements is on the shorter vs. longer time horizons with wage rigidity, we plot in Figure 4 the differences in downward-rigid nominal wage correlations between the fixed and flexible regimes for one-period (Figure 2) and four-period (Figure 3) experiments. Figure 4 suggests that, when the time horizon is shorter, the positive effect of fixed exchange rate regimes on nominal wage comovements is weaker. In other words, the longer the time horizon is, the stronger the positive effect is. This is because, as time goes by, inflation and productivity growth tend to lift equilibrium nominal wages and hence downward rigidity is less likely to be binding.

2.4 Comovements of real variables

So far we have focused on nominal wages. Immediately, a natural question is whether our findings about nominal wages can be extended to real wages and other real variables such as real exchange rate, consumption, labor, and output. First, given that our model features flexible prices and wages, it is intuitive that money is neutral and that the comovements of the real variables are not affected by exchange rate regimes. In particular, the choice of exchange rate regime should not affect real wage comovements in our model. We test this hypothesis in the regressions.

Next, as in Section 2.3, we carry out numerical experiments to study the effect of trade costs and downward nominal wage rigidity. Figure 5 is the real wage counterpart for Figure 1. As can be seen, a reduction in trade costs tends to increase real wage comovements under both exchange rate regimes. Figures 6 to 8 are the real wage counterparts for Figures 2 to 4, respectively. When downward nominal wage rigidity is introduced, comovements in real wages decline slightly under both regimes, and there appears a small difference between the real wage comovements under the two regimes. Unlike the results for nominal wage comovements, the relative effects of the fixed regime on real wage comovements are larger on the shorter time horizon, albeit the differences in correlations are small in magnitude.

Intuitively, when both nominal prices and wages are flexible, changes in money supply affect nominal prices and wages in similar ways, leaving the real wages unaffected by monetary factors. However, if nominal wages are less flexible than prices due to downward nominal wage rigidity, then changes in the money supply will affect real wages. When two countries peg their exchange rate, money supplies will have similar effects on real wages in the two countries. This will lead to real wage comovements, which will be stronger on the shorter time horizon when downward rigidity is more likely to be binding. However, a full investigation of the role of wage rigidity is beyond the scope of this paper.

Finally, it is worth pointing out that our model is related to the literature on the relationship between real exchange rates and the relative price of nontradable goods. Two recent papers on the subject, Betts and Kehoe (2006, 2008), find that for pairs of countries that trade intensively or maintain a stable bilateral real exchange rate, the relative price of nontradable goods has a stronger relationship with their bilateral real exchange rate. Our Ricardian model implies a similar relationship. Substituting $P_t^j(z) = W_t^j/A_t^j(z)$ into equation (2) gives

$$e_t \frac{P_t^F}{P_t^H} = D_t \left(e_t \frac{P_t^F(z)}{P_t^H(z)} \right)^{1-\epsilon}.$$

This indicates a simple decomposition of the real exchange rate into two components—one due to failures of the law of one price, and the other due to cross-country fluctuations in the relative price of nontradable goods. Suppose now that trade costs are zero ($\tau = 0$), that is, trade intensity is the largest. Then the law of one price holds ($D_t = 1$), and thus the real exchange rate is determined completely by the relative price of nontradable goods.

3 Empirical Evidence

To test our theory, we empirically examine the comovements between the wage growth rates of a country and its trade partner and how the wage comovements may be affected by exchange rate regimes, trade costs, and downward nominal wage rigidity.

3.1 Regression specification

We derive the regression specifications from our theory. Proposition 1 and assumption (d) about productivity processes imply that

$$\begin{aligned} ln\left(\frac{W_t^H}{W_{t-1}^H}\right) &= ln\left(\frac{W_t^F}{W_{t-1}^F}\right) + \frac{\epsilon}{\epsilon-1}\cdot ln\left(\frac{e_t}{e_{t-1}}\right) + \frac{1}{1-\epsilon}\cdot ln\left(\frac{D_t}{D_{t-1}}\right) + \frac{1}{1-\epsilon}\cdot ln\left(\frac{P_t^H}{P_{t-1}^H}\frac{P_{t-1}^F}{P_t^F}\right) \\ &+ \left(\Delta a_t^H(z) - \Delta a_t^F(z)\right) + \left(\rho^H(z)\,\alpha_{t-1}^H(z) - \rho^F(z)\,\alpha_{t-1}^F(z)\right) + \left(v_t^H - v_t^F\right). \end{aligned} \quad (4)$$

This equation suggests a linear regression of home nominal wage growth on foreign nominal wage growth, the change in the nominal exchange rate, the change in the price index of tradable goods, inflation differential, and the trend and cyclical components of productivities.

To test the prediction of Proposition 2 that the nominal wage comovements will be stronger under the fixed exchange rate regime, we include the interaction term between the fixed exchange rate regime and foreign nominal wage growth in the following estimation equation. Because our numerical experiments suggest that the trade costs are negatively correlated with nominal wage comovements regardless of exchange rate regimes, we add trade intensity, a variable inversely related to τ, to the regression and interact it with the changes in foreign nominal wages. In addition to trade and exchange rates, it is known that migration and capital movements can also affect wage comovements.[7] Hence, we add these two variables and their interactions with foreign nominal wage growth to the regression.

[7]There is a vast literature on trade and migration. Dornbusch et al. (1977) and Trefler (1997), for example, analyze the effects of immigration in a model of Ricardian trade with a continuum of goods. They consider a change in relative size as immigration. Then nominal wages in the host country fall to produce goods with relatively low productivity that were not previously produced in the host country. Likewise, nominal wages in the home country rise to shut down goods with relatively low productivity that were previously produced in the home country. Thus immigration causes nominal wages to fall in the host country but to rise in the home country, changing the range of goods produced in each country. It can also be shown that real wages fall in the host country but rise in the home country. Migration can thus cause the (negative) comovements of both nominal and real wages.

There is also a sizable literature on trade and capital movements. For example, a well-known argument concerns trade vs. capital movements in the H-O model. Consider the Dixit and Norman (1980) integrated world equilibrium in an integrated economy in which goods and factors are free to move across countries. Then trade in goods can achieve this integrated world equilibrium without factor movements across countries. Alternatively, capital movements can also achieve it without trade in goods (or labor mobility across countries). Thus capital movements are substitutes for trade in goods. In either case, after trade or capital movements, factor prices become equalized across countries. That is, nominal wages go up in one country but go down in the other country. It can also be shown by the Stolper-Samuelson argument that real wages go up in one country but go down in the other country. Thus capital movements can provide an alternative to trade as a cause of (negative) comovements of both nominal and real wages.

Thus our regression specification is

$$
\begin{aligned}
ln\left(\frac{W_{kt}^{H}}{W_{kt-1}^{H}}\right) = {} & \beta_0 + \beta_1 \cdot ln\left(\frac{W_{kt}^{F}}{W_{kt-1}^{F}}\right) + \beta_2 \cdot peg_{kt} \cdot ln\left(\frac{W_{kt}^{F}}{W_{kt-1}^{F}}\right) + \beta_3 \cdot peg_{kt} \\
& + \beta_4 \cdot trade_{kt} \cdot ln\left(\frac{W_{kt}^{F}}{W_{kt-1}^{F}}\right) + \beta_5 \cdot trade_{kt} + \beta_6 \cdot FDI_{kt} \cdot ln\left(\frac{W_{kt}^{F}}{W_{kt-1}^{F}}\right) + \beta_7 \cdot FDI_{kt} \\
& + \beta_8 \cdot migration_{kt} \cdot ln\left(\frac{W_{kt}^{F}}{W_{kt-1}^{F}}\right) + \beta_9 \cdot migration_{kt} \\
& + \beta_{10} \cdot ln\left(\frac{e_{kt}}{e_{kt-1}}\right) + \beta_{11} \cdot ln\left(\frac{D_{kt}}{D_{kt-1}}\right) + \beta_{12} \cdot ln\left(\frac{P_{kt}^{H}}{P_{kt-1}^{H}}\frac{P_{kt-1}^{F}}{P_{kt}^{F}}\right) \\
& + \beta_{13} \cdot \left(\Delta a_{kt}^{H}(z) - \Delta a_{kt}^{F}(z)\right) + \beta_{14} \cdot \alpha_{kt-1}^{H}(z) + \beta_{15} \cdot \alpha_{kt-1}^{F}(z) + \epsilon_{kt},
\end{aligned}
\tag{5}
$$

where W_{kt}^{H} is the nominal wage index of country k; W_{kt}^{F} is the nominal wage index for the base country of country k; peg_{kt} is a dummy variable that is equal to 1 if country k pegs its exchange rate to its base country, and 0 otherwise; $trade_{kt}$ is a measure for trade intensity between country k and its base country; FDI_{kt} and $migration_{kt}$ are measures for bilateral FDI and migration, respectively; e_{kt} is the nominal exchange rate between country k and its base country; D_{kt} is the ratio of the CPI of tradable goods in country k's base country to its counterpart in country k; P_{kt}^{H} and P_{kt}^{F} are country k's CPI and its base country's CPI, respectively; $\Delta a_{kt}^{H}(z) - \Delta a_{kt}^{F}(z)$ is the difference in changes in the trends of nontradable-sector labor productivities between country k and its base country; $\alpha_{kt-1}^{H}(z)$ and $\alpha_{kt-1}^{F}(z)$ are lag levels of cyclical productivities of country k and its base country, respectively; and ϵ_{kt} is the error term that contains the productivity shock term $v_{kt}^{H} - v_{kt}^{F}$ and other disturbances. In actual regressions, we also include country fixed effects to control for the influence of other time-invariant country characteristics.

Our intention is to use the regression analysis to estimate the partial correlation between home and foreign nominal wage growth rates under different exchange rate regimes. We do not intend to identify the causality between nominal wages because they are equilibrium objects. In particular, our main interest is in the parameter β_2, which measures the additional nominal wage comovements experienced by countries with a fixed exchange rate regime relative to those with a flexible regime. Proposition 2 is substantiated if $\beta_2 > 0$.

Our model implies that the exchange rate regime does not affect real wage comovements. To test this implication, we estimate an equation that is identical to equation (5) except that nominal wages are replaced with real wages. If the coefficient on the interaction between the peg variable and foreign real wage growth, β_2, is statistically insignificant, then the implication of our model with regard to real wage comovements is supported.

Our numerical experiments suggest that a reduction in trade costs increases both nominal and real wage comovements. Given that trade intensity is usually negatively associated with trade costs, we expect the coefficient on the interaction between trade intensity and foreign wage growth, β_4, to be positive.

Meanwhile, in our numerical experiments with downward nominal wage rigidity, the nominal wage comovements under the fixed exchange rate regime remain stronger than under the flexible regime, and the difference between the two regimes is smaller on the shorter time horizon. In contrast, the difference in real wage comovements between the two regimes is larger on the shorter time horizon. To test these predictions, we run regressions with variables defined at one-year and four-year frequencies, respectively, under the premise that nominal wage rigidity is more likely to be present at the one-year frequency. Based on the results of numerical experiments, we expect that in regressions with nominal wage growth, β_2 is positive and significant in both annual and quadrennial regressions, and that it is smaller in the annual regressions. In regressions with real wage growth, we expect that β_2 is more positive in the annual regressions than in the quadrennial regressions.

Lastly, because our specification incorporates trends in productivity, the wage comovements that we examine empirically are the cyclical fluctuations in wages around trends.

3.2 Data

Our regression analysis uses nominal wage data from the OECD Library (www.oecd-ilibrary.org), which provides detailed wage information of OECD countries. Nominal wages are measured by the index for nominal hourly earnings in manufacturing sectors.[8] Our choice of nominal wage measurement, identical to that in Levchenko and Zhang (2016), is consistent with the theory that requires a country-specific measure for nominal wages.

Our definition of peg is based on Ilzetzki, Reinhart and Rogoff (2011) who draw on national sources, and secondary sources, such as the Picks Black Market Yearbook and the International Financial Statistics (IFS), to classify exchange rate regimes into six types. In the order of increasing flexibility, the categories are (1) no separate legal tender, pre-announced peg or currency board arrangement, pre-announced horizontal band that is narrower than or equal to +/-2%, and de facto peg; (2) pre-announced crawling peg, pre-announced crawling band that is narrower than or equal to +/-2%, de facto crawling peg, and de facto crawling band that is narrower than or equal to +/-2%; (3) pre-announced crawling band that is wider than or equal to +/-2%, de facto crawling band that is narrower than or equal to +/-5%, moving band that is narrower than or equal to +/-2%, and managed floating; (4) freely floating; (5) freely falling; and (6) dual market in which parallel market data are missing. We define regimes of type (1) and type (2) as a peg and the other four types of regimes as flexible.

In our model, we implicitly assume that the exchange rate peg is credible. In practice, however, non-currency-union pegs often lack credibility compared to the currency union (Obstfeld and Rogoff, 1995b).[9] Historically, countries had been known to break their pegs and devalue when the prices of their products were not competitive internationally. If economic agents expect such devaluations, then there are smaller incentives to align nominal wages to the base country. In contrast, being in a currency union constitutes a credible exchange rate peg to other union members as the same currency is used by all countries in the union and it is costly to exit the union. It is thus possible that these two types of pegs have different effects on wage comovements. Therefore, in many regressions, we redefine the peg regime to be the currency union and interact the currency

[8]The OECD Library does not provide hourly earnings data on Greece and Switzerland, so we use the average annual wages to calculate wage growth rates for these two countries. Excluding them from the sample does not affect our findings.

[9]As Obstfeld and Rogoff (1995b) mention, Eichengreen (1994), Obstfeld (1985), and Svensson (1994) argue that fixed exchange rates are inherently fragile.

union indicator with the foreign wage growth. In such regressions, the reference group includes countries that adopt a flexible exchange rate regime and countries that engage in non-currency-union pegs. We argue that these two types of countries are similar in the sense that flexibility in exchange rate, to different extents, is expected.

Our measure of trade intensity is the ratio of bilateral trade volume to the product of the square roots of the GDP of the two countries, i.e., $trade^{HF}/\sqrt{GDP^H \cdot GDP^F}$. We obtain trade volume data from the UN Comtrade dataset and GDP data from the IFS. We measure capital flow as the average of two ratios: the ratio of FDI flow from the base country to the home country to the home GDP, and its counterpart of the base country.[10] Similarly, migration is the average of two ratios: the ratio of migrants from the base country to the home country to the home population, and its counterpart of the base country. The data on FDI and migration are obtained from the OECD Library.

To the best of our knowledge, there are no systematic data on labor productivity in the nontradable sector, so we use labor productivity in the overall economy instead. For country k and its base country, we obtain real output per worker from the Penn World Table, and apply the Hodrick-Prescott filter to extract the trend components, $a^H_{kt}(z)$ and $a^F_{kt}(z)$, and the cyclical components, $\alpha^H_{kt}(z)$ and $\alpha^F_{kt}(z)$, respectively.

The measure that we use for the term D_{kt} is the ratio of the CPI of tradable goods in country k's base country to its counterpart in country k. We construct the CPI of tradable goods for country k, CPI^k_T, as

$$\begin{aligned} CPI^k_T &= \left(\frac{1}{\omega^k_T}\right)\left(CPI^k - \omega^k_S \cdot CPI^k_S - \omega^k_R \cdot CPI^k_R\right) \\ &= \left(\frac{1}{1-\omega^k_S-\omega^k_R}\right)\left(CPI^k - \omega^k_S \cdot CPI^k_S - \omega^k_R \cdot CPI^k_R\right) \end{aligned}$$

where ω^k_T, ω^k_S, and ω^k_R are the weight of tradable goods, services, and housing in the CPI, respectively. CPI^k is the overall CPI, while CPI^k_T, CPI^k_S, and CPI^k_R are the corresponding sub-indices for tradable goods, services, and housing, respectively. When

[10] We do not use the geometric mean because the geometric mean becomes zero when either FDI flow is zero.

CPI_S^k and CPI_R^k are unavailable, we simply use the overall CPI as a proxy for the tradable CPI.[11] The CPI data are obtained from the OECD Library.

The countries in our sample are 33 OECD members with wage data available, including Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom, and United States.[12] Because we are looking at OECD countries, the currency union is the EMU. Our sample covers data from 1971 to 2012. Details about the base country, episodes of exchange rate pegs, and data range for each country are documented in Table 1. We report summary statistics in Table 2.

We use the base countries definition of Klein and Shambaugh (2006). To be specific, country k's base country is the country to which country k pegs its exchange rate or the country with which country k has the most significant trade relationship.

3.3 Main regression results

We run regressions with growth rates of nominal wages calculated over one year and four years to check whether regression results differ in the short run and in the long run as the one-period and four-period experiments with downward nominal wage rigidity suggest. The top rows in Tables 3 to 6 indicate the frequency of the data.

Table 3 reports the nominal wage comovements under different exchange rate regimes. In the odd-numbered columns, a country's exchange rate regime is considered to be fixed if it falls into type (1) or type (2) of Ilzetzki, Reinhart and Rogoff (2011). We will refer to this peg definition as a general peg. For general pegs, the coefficients on the interaction term $peg_{kt} \times \Delta ln(W_{kt}^F)$ are positive, but not statistically significant, suggesting that Proposition 2 receives little support.

[11] There are 11 countries for which we use the overall CPI to proxy for the tradable CPI. We conduct a robustness check that uses the overall CPI for all countries in the regression and find very similar results.

[12] The only OECD country not included in our sample is Chile due to missing data. Israel and Slovakia joined the OECD in 2010, and excluding these two countries does not change our empirical results.

As discussed in Section 3.2, however, it may not be appropriate to assume that the non-currency-union pegs and the monetary union have the same credibility and combine them to create a single indicator variable for pegs. Given that being in the EMU is a more credible exchange rate peg than a non-currency-union peg, we focus on the effects of the EMU and thus define an indicator variable for this type of peg, EMU_{kt}. It is equal to 1 if country k and its base country are both in the EMU in period t, and 0 otherwise.

We report the results associated with this EMU indicator in even-numbered columns in Table 3. The interaction between the EMU indicator and nominal wage growth in the base country, $EMU_{kt} \times \Delta ln(W_{kt}^F)$, is always positive and significant, suggesting that being in the EMU is associated with stronger nominal wage comovements. The magnitude of the coefficient is also economically significant. For instance, at the annual frequency, the coefficient on the interaction term $EMU_{kt} \times \Delta ln(W_{kt}^F)$ is 1.65. It implies that if the nominal wages in country k's base country increase by 1%, being in the EMU with the base country predicts an additional increase of 1.65% in country k's nominal wages relative to cases where a country floats its exchange rate against the base country or engages in a non-currency-union peg.

The interaction between trade intensity and nominal wage growth in the base country is also positive and significant, confirming the result of numerical experiments that higher trade intensity is associated with stronger nominal wage comovements. We also find weak evidence for the numerical analysis result that the enhancing effect of the fixed exchange rate regime on nominal wage comovements is smaller on the shorter time horizon. In the annual regression where rigidity is more likely, the coefficient on the interaction between the EMU indicator and nominal wage growth of the base country is 1.65, which is smaller than the coefficient of 2.49 in the quadrennial regression. However, the difference (-0.84) is statistically insignificant. Overall, the results are largely consistent with Proposition 2 and the numerical experiments related to trade costs and downward nominal wage rigidity.

In the regressions in Table 3, the interaction between FDI and foreign nominal wage growth is always insignificant. Meanwhile, the interaction related to migration is negative and significant at annual frequency, which is consistent with the prediction of Dornbusch et al. (1977) and Trefler (1997).

We also use all countries pairs to conduct a robustness check. The results are weaker in the sense that the effect of the EMU on wage comovements is only significant at the four-year frequency. Because our theory involves a two-country trade model, it is suitable to use the data of countries and their main trade partners to test the theoretical predictions.

3.4 EMU countries vs. non-EMU countries

In Table 4, we repeat the estimations in Table 3 but restrict the sample to 15 countries currently in the EMU. More specifically, the countries included are Austria, Belgium, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Slovakia, Slovenia, and Spain. The time range remains 1971 to 2012. The purpose of these estimations is to check whether nominal wage comovements became more positive during the EMU era than the pre-EMU era. Compared to Table 3, the coefficient of the interaction term $EMU_{kt} \times \Delta ln(W_{kt}^F)$ in Table 4 remains positive, and is highly significant at the quadrennial frequency.[13] Hence, for the same 15 countries, there is some evidence that the positive nominal wage comovements with their base countries after joining the EMU are stronger than before joining the EMU. The results related to trade intensity, FDI, and migration are similar to those in Table 3.

We also run regressions with the countries not in the EMU to examine whether non-currency-union pegs affect nominal wage comovements. The results presented in Table 5 indicate that non-currency-union pegs have no statistically significant strengthening effect on nominal wage comovements in non-EMU countries.

[13] It is close to being significant at the 10% level at the annual frequency, with the $t-$statistic equal to 1.63.

3.5 Real wage comovements

To examine whether exchange rate regimes affect real wage comovements, we repeat the regressions in Table 3, but use real wage growth instead of nominal wage growth. The results are presented in Table 6. The coefficient of the interaction between the EMU indicator and the foreign real wage growth, $EMU_{kt} \times \Delta\ ln(real\ W_{kt}^{F})$, is 0.26 in the annual regression, and it is -3.15 in the quadrennial regression. Because both coefficients are statistically insignificant, the evidence supports the hypothesis that the exchange rate regime should not affect real wage comovements. Consistent with the results of numerical experiments, the effect of the fixed regime on real wage comovements is more positive on the shorter time horizon where it is more likely that nominal wage rigidity plays a role, although the difference between the coefficients is statistically insignificant. Meanwhile, the coefficient of the interaction between trade intensity and foreign real wage growth is always positive and significant, lending support to the results of numerical experiments that a reduction in trade costs boosts real wage comovements.

When we restrict the sample to the EMU members and the non-EMU countries, respectively, the results are very similar to those for nominal wage comovements reported above and hence are not reported here. Overall, the evidence is generally consistent with our model and numerical experiments.

4 Conclusions

We have constructed a Ricardian model of trade with money and trade costs and obtained the prediction that two countries' nominal wages must exhibit strong and positive comovements if they fix the bilateral exchange rate. Meanwhile, comovements of real wages are not affected by the choice of exchange rate regime. Using numerical experiments, we have also shown that a reduction in trade costs tends to increase both nominal and real wage comovements regardless of exchange rate regimes. When downward nominal wage rigidity is introduced into the numerical experiments, the strengthening effect of the fixed regime on nominal wage comovements remains and is weaker on the shorter time horizon, while a slight difference in real wage comovements between the two regimes shows up and is larger on the shorter time horizon. We have used the data of 33 OECD countries between 1971 and 2012 to test these predictions. Based on panel regressions, we have three main empirical findings. First, if a country and its main trade partner were in the EMU, their nominal wages experienced significantly stronger comovements in both the short and long run. However, non-currency-union pegs are not associated with stronger nominal wage comovements. Second, the effect of pegs on real wage comovements is more positive in the short run than in the long run, although statistically insignificant. Third, the larger the trade intensity between the two countries, the stronger the comovements of both nominal and real wages. These findings are largely consistent with our model and numerical experiments.

Our work enhances the understanding of wages in international economics in a number of ways. It adds to (1) the literature on exchange rates and wages by highlighting the role of exchange rate regimes; (2) the literature on nominal wage comovements by showing that fixing exchange rate to a major trade partner can provide a nominal anchor for wages; (3) the literature on the relationship between exchange rates and macroeconomic real variables; and (4) the literature on real exchange rates and the relative price of nontradable goods.

In addition, from a policy perspective, our empirical results are also relevant for the debate over whether the EMU is an optimum currency area. The existence of nominal wage comovements suggests that although relative to the US, the EMU originally was less likely to meet the criteria for an optimum currency area (Feenstra and Taylor, 2008, p.879), it may have enhanced the economic integration of its members via nominal wage comovements.

Finally, we note that Schmitt-Grohé and Uribe (2013) have recently found that there were not enough downward movements of nominal wages in the Eurozone after the crisis. It indicates that due to this downward nominal wage rigidity, the nominal wage comovements that we have documented may not contain enough downward movements.

Appendix A. Supplementary appendix

Supplementary appendix to this article can be found online at http://dx.doi.org/10.1016/j.jinteco.2016.06.002.

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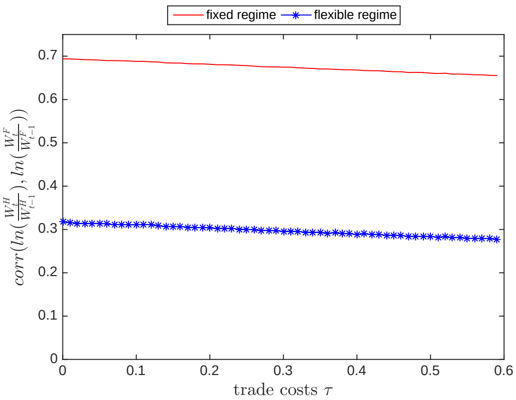

Figure 1: Nominal wage comovements with no rigidity

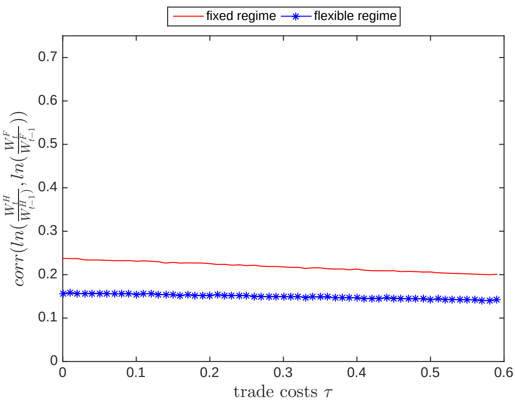

Figure 2: Nominal wage comovements with downward nominal wage rigidity, one-period wage growth

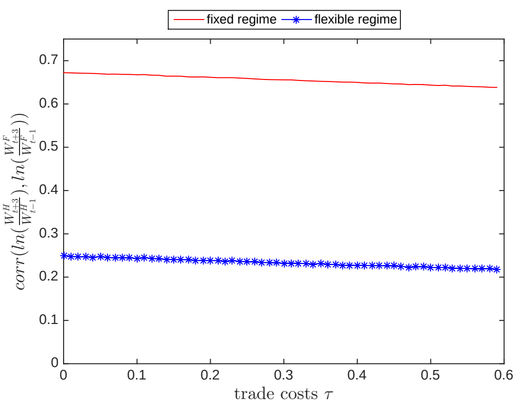

Figure 3: Nominal wage comovements with downward nominal wage rigidity, four-period wage growth

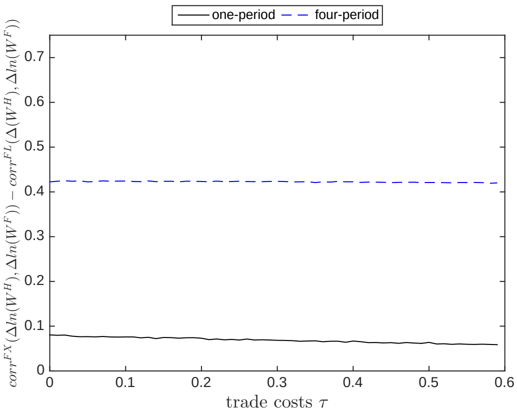

Figure 4: Difference in nominal wage comovements between fixed and flexible regimes, with downward nominal wage rigidity: one- vs. four-period growth

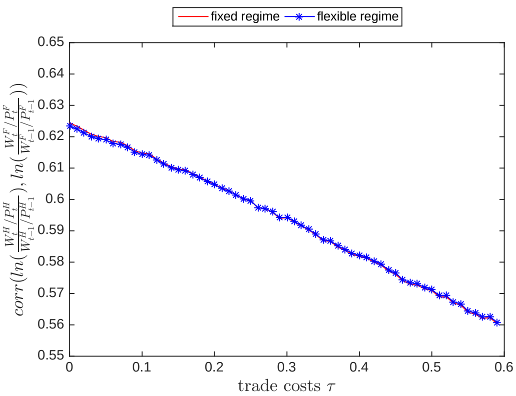

Figure 5: Real wage comovements with no rigidity

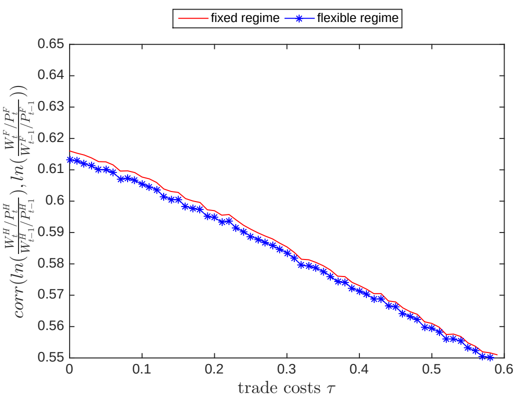

Figure 6: Real wage comovements with downward nominal wage rigidity, one-period wage growth

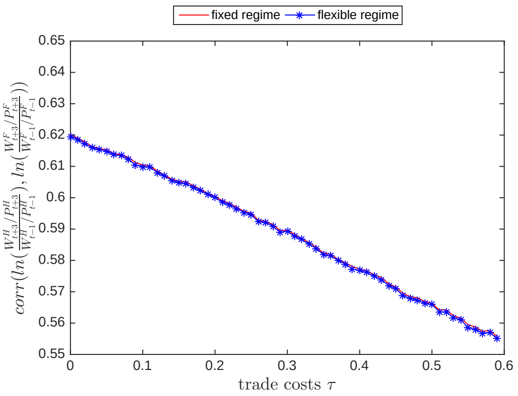

Figure 7: Real wage comovements with downward nominal wage rigidity, four-period wage growth

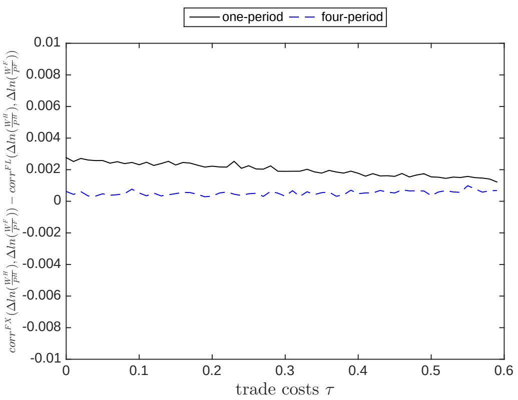

Figure 8: Difference in real wage comovements between fixed and flexible regimes, with downward nominal wage rigidity: one- vs. four-period growth

Table 1: Summary of peg episodes and data range

Country	Base country	Episodes of non-currency-union pegs with base country	Wage data range
EMU members (since year)			
Austria (1999)	Germany	1971-1998	1971-2012
Belgium (1999)	Germany	1971-1998	1971-2012
Estonia (2011)	Germany	1995-2010	2000-2012
Finland (1999)	Germany	1971-1991, 1994-1998	1971-2012
France (1999)	Germany	1971-1973, 1975-1998	1971-2012
Germany (1999)	US	1972	1971-2012
Greece (2001)	Germany	1971-1980, 1985-1998	1996-2012
Ireland (1999)	Germany	1979-1998	1979-2012
Italy (1999)	Germany	1971-1974, 1983-1991, 1994-1998	1971-2012
Luxembourg (1999)	Belgium	1971-1998	1999-2012
Netherlands (1999)	Germany	1971-1998	1971-2012
Portugal (1999)	Germany	1971-1972, 1982-1998	2000-2012
Slovakia (2009)	Germany	1994-1996, 1999-2008	1993-2012
Slovenia (2007)	Germany	1994-2006	1998-2012
Spain (1999)	Germany	1971-1998	1981-2012
Country in ERM II			
Denmark	Germany	1971-2012	1971-2012
Other countries			
Australia	US	1971-1981	1984-2012
Canada	US	1971-2001	1971-2012
Czech Republic	Germany	1993-1995, 1998-2001	1993-2012
Iceland	Germany	1987-1999	2005-2012
Israel	US	1987-1990, 1994-2004	1995-2012
Japan	US	1972-1976	1971-2012
Korea	US	1975-1996	1992-2012
Mexico	US	1971-1975, 1978-1981, 1989-1994	1980-2012
Hungary	Germany	1995-2004	1995-2012
New Zealand	Australia	1971-1984	1989-2012
Norway	Germany		1971-2012
Poland	Germany	1990	1995-2012
Sweden	Germany	1971-1991	1971-2012
Switzerland	Germany	1982-1998	1991-2012
Turkey	US	1971	1988-2012
UK	Germany	1971, 1991	1971-2012
US	Japan	1972-1976	1971-2012

Notes: (1) Prior to 1979, the UK had been the base country for Ireland, as the Irish pound had been pegged to the pound sterling. In all regressions, we discard the Irish data before 1979 to avoid complications. (2) ERM II stands for Exchange Rate Mechanism II.

Table 2: Summary statistics

	Mean	Standard deviation	Min	Max	Country-year observations
Annual change in nominal wage (%)					
Flexible	8.53	13.54	-5.96	91.57	428
Non-currency-union pegs	8.46	6.01	0.0	29.32	229
EMU	5.96	5.10	-5.27	25.22	506
Annual change in nominal exchange rate (%)					
Flexible	3.80	17.47	-30.34	138.63	428
Non-currency-union pegs	2.61	6.61	-9.68	40.55	229
EMU	0	0	0	0	506

Notes: We classify country-year observations into three categories according to exchange rate regimes: flexible regime, non-currency-union pegs, and membership in the EMU.

Table 3: Nominal wage regressions

	Annual	Annual	Quadrennial	Quadrennial
	(1)	(2)	(3)	(4)
$\Delta ln(W^F_{kt})$	-1.22	-1.15	-1.30	-1.16
	(0.49)**	(0.48)**	(0.58)**	(0.58)**
$peg_{kt} \times \Delta ln(W^F_{kt})$	0.37		0.27	
	(0.44)		(0.49)	
peg_{kt}	0.001		0.007	
	(0.01)		(0.04)	
$EMU_{kt} \times \Delta ln(W^F_{kt})$		1.65		2.49
		(0.51)***		(0.36)***
EMU_{kt}		0.03		0.16
		(0.01)**		(0.04)***
$trade_{kt} \times \Delta ln(W^F_{kt})$	0.26	0.27	0.27	0.29
	(0.08)***	(0.08)***	(0.09)***	(0.09)***
$trade_{kt}$	0.001	0.002	-.01	-.004
	(0.004)	(0.005)	(0.03)	(0.03)
$FDI_{kt} \times \Delta ln(W^F_{kt})$	-.20	-.23	0.38	0.19
	(0.13)	(0.14)	(0.51)	(0.55)
FDI_{kt}	-.001	-.001	0.03	0.02
	(0.001)	(0.001)	(0.03)	(0.03)
$migration_{kt} \times \Delta ln(W^F_{kt})$	-.02	-.02	-.01	-.001
	(0.003)***	(0.007)***	(0.007)	(0.03)
$migration_{kt}$	0.000	-.000	0.001	0.001
	(0.001)	(0.001)	(0.0005)*	(0.002)
$\Delta ln(e_{kt})$	-.02	-.06	-.42	-.43
	(0.06)	(0.04)	(0.21)**	(0.23)*
$\Delta ln(D_{kt})$	-.03	-.01	0.36	0.32
	(0.05)	(0.04)	(0.22)	(0.22)
$\Delta ln(P^H_{kt}) - \Delta ln(P^F_{kt})$	0.20	0.24	0.65	0.67
	(0.11)*	(0.12)**	(0.37)*	(0.38)*
$\Delta a^H_{kt}(z) - \Delta a^F_{kt}(z)$	0.06	0.07	0.28	0.30
	(0.03)*	(0.04)**	(0.14)*	(0.16)*
$\alpha^H_{kt-1}(z)$	0.23	0.22	1.64	1.60
	(0.08)***	(0.10)**	(1.89)	(2.06)
$\alpha^F_{kt-1}(z)$	0.02	-.05	-3.93	-4.21
	(0.12)	(0.13)	(3.06)	(3.32)
Obs.	1163	1008	290	261
R^2	0.19	0.21	0.33	0.35

Notes: (1) The dependent variable is the nominal wage growth rate of country k. (2) $\Delta\ ln(W^F_{kt})$ is the nominal wage growth rate of the base country; peg_{kt} equals 1 if country k pegs its currency to that of its base country via a currency union or other arrangements, and 0 otherwise; EMU_{kt} equals 1 if both country k and its base country are members of the EMU, and 0 otherwise; $trade_{kt}$ is a measure for trade intensity between country k and its base country; FDI_{kt} and $migration_{kt}$ are measures for bilateral FDI and migration, respectively; e_{kt} is the bilateral nominal exchange rate; D_{kt} is the ratio of the CPI of tradable goods in country k's base country to its counterpart in country k; P^H_{kt} and P^F_{kt} are country k's CPI and its base country's CPI, respectively; $\Delta a^H_{kt}(z) - \Delta a^F_{kt}(z)$ is the difference in the changes of deterministic components of nontradable productivities; $\alpha^H_{kt-1}(z)$ and $\alpha^F_{kt-1}(z)$ are the cyclical components of nontradable productivities in country k and its base country, respectively. (3) The top row indicates the frequency of the data. (4) The numbers in the parentheses are clustered standard errors that are robust to heteroskedasticity across countries and serial correlation in error terms. (5) All regressions include country fixed effects. (6) *, **, and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively.

Table 4: Nominal wage regressions: restricting the sample to EMU countries

	Annual	Annual	Quadrennial	Quadrennial
	(1)	(2)	(3)	(4)
$\Delta ln(W^F_{kt})$	-.23 (0.33)	-.43 (0.56)	-.28 (0.44)	-.35 (0.51)
$peg_{kt} \times \Delta ln(W^F_{kt})$	-.22 (0.48)		-.44 (0.63)	
peg_{kt}	0.001 (0.01)		-.003 (0.06)	
$EMU_{kt} \times \Delta ln(W^F_{kt})$		0.44 (0.27)		1.79 (0.45)***
EMU_{kt}		0.02 (0.008)***		0.14 (0.03)***
$trade_{kt} \times \Delta ln(W^F_{kt})$	0.18 (0.09)*	0.19 (0.08)**	0.20 (0.12)*	0.20 (0.09)**
$trade_{kt}$	-.004 (0.004)	0.003 (0.004)	-.02 (0.02)	0.02 (0.02)
$FDI_{kt} \times \Delta ln(W^F_{kt})$	-.18 (0.12)	-.11 (0.07)	-.65 (0.5)	-.17 (0.55)
FDI_{kt}	-.001 (0.001)	-.0003 (0.001)	-.05 (0.04)	-.01 (0.04)
$migration_{kt} \times \Delta ln(W^F_{kt})$	-.02 (0.004)***	-.02 (0.006)***	-.02 (0.009)**	-.04 (0.02)*
$migration_{kt}$	0.000 (0.001)	-.000 (0.001)	0.001 (0.001)	-.001 (0.001)
$\Delta ln(e_{kt})$	0.12 (0.12)	-.06 (0.10)	-.02 (0.40)	-.86 (0.54)
$\Delta ln(D_{kt})$	-.10 (0.10)	0.04 (0.11)	-.001 (0.38)	0.66 (0.57)
$\Delta ln(P^H_{kt}) - \Delta ln(P^F_{kt})$	-.06 (0.10)	0.19 (0.19)	0.17 (0.41)	1.03 (0.59)*
$\Delta a^H_{kt}(z) - \Delta a^F_{kt}(z)$	0.02 (0.06)	-.04 (0.05)	0.05 (0.28)	-.21 (0.28)
$\alpha^H_{kt-1}(z)$	0.26 (0.09)***	0.24 (0.10)**	0.98 (1.25)	0.60 (0.98)
$\alpha^F_{kt-1}(z)$	-.12 (0.10)	-.11 (0.15)	-.76 (2.10)	0.74 (1.22)
Obs.	511	403	128	104
R^2	0.42	0.52	0.5	0.64

Notes: (1) The dependent variable is the nominal wage growth rate of country k. (2) $\Delta\ ln(W^F_{kt})$ is the nominal wage growth rate of the base country; peg_{kt} equals 1 if country k pegs its currency to that of its base country via a currency union or other arrangements, and 0 otherwise; EMU_{kt} equals 1 if both country k and its base country are members of the EMU, and 0 otherwise; $trade_{kt}$ is a measure for trade intensity between country k and its base country; FDI_{kt} and $migration_{kt}$ are measures for bilateral FDI and migration, respectively; e_{kt} is the bilateral nominal exchange rate; D_{kt} is the ratio of the CPI of tradable goods in country k's base country to its counterpart in country k; P^H_{kt} and P^F_{kt} are country k's CPI and its base country's CPI, respectively; $\Delta a^H_{kt}(z) - \Delta a^F_{kt}(z)$ is the difference in the changes of deterministic components of nontradable productivities; $\alpha^H_{kt-1}(z)$ and $\alpha^F_{kt-1}(z)$ are the cyclical components of nontradable productivities in country k and its base country, respectively. (3) The top row indicates the frequency of the data. (4) The numbers in the parentheses are clustered standard errors that are robust to heteroskedasticity across countries and serial correlation in error terms. (5) All regressions include country fixed effects. (6) *, **, and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively.

Table 5: Nominal wage regressions: restricting the sample to non-EMU countries

	Annual	Quadrennial
	(1)	(2)
$\Delta ln(W_{kt}^F)$	-1.48	-1.60
	(0.64)**	(0.65)**
$peg_{kt} \times \Delta ln(W_{kt}^F)$	0.06	0.68
	(0.55)	(0.70)
peg_{kt}	0.003	-.003
	(0.02)	(0.05)
$trade_{kt} \times \Delta ln(W_{kt}^F)$	0.38	0.34
	(0.14)***	(0.14)**
$trade_{kt}$	0.001	-.02
	(0.005)	(0.04)
$FDI_{kt} \times \Delta ln(W_{kt}^F)$	-.44	-.23
	(0.59)	(1.38)
FDI_{kt}	0.02	0.22
	(0.01)**	(0.09)**
$migration_{kt} \times \Delta ln(W_{kt}^F)$	-.01	0.06
	(0.01)	(0.05)
$migration_{kt}$	-.000	0.005
	(0.001)	(0.003)
$\Delta ln(e_{kt})$	-.04	-.43
	(0.05)	(0.23)*
$\Delta ln(D_{kt})$	-.04	0.34
	(0.05)	(0.21)*
$\Delta ln(P_{kt}^H) - \Delta ln(P_{kt}^F)$	0.23	0.66
	(0.12)*	(0.38)*
$\Delta a_{kt}^H(z) - \Delta a_{kt}^F(z)$	0.07	0.37
	(0.03)**	(0.16)**
$\alpha_{kt-1}^H(z)$	0.22	1.61
	(0.13)*	(2.48)
$\alpha_{kt-1}^F(z)$	0.05	-6.11
	(0.19)	(4.15)
Obs.	652	162
R^2	0.2	0.36

Notes: (1) The dependent variable is the nominal wage growth rate of country k. (2) $\Delta\ ln(W_{kt}^F)$ is the nominal wage growth rate of the base country; peg_{kt} equals 1 if country k pegs its currency to that of its base country via a currency union or other arrangements, and 0 otherwise; $trade_{kt}$ is a measure for trade intensity between country k and its base country; FDI_{kt} and $migration_{kt}$ are measures for bilateral FDI and migration, respectively; e_{kt} is the bilateral nominal exchange rate; D_{kt} is the ratio of the CPI of tradable goods in country k's base country to its counterpart in country k; P_{kt}^H and P_{kt}^F are country k's CPI and its base country's CPI, respectively; $\Delta a_{kt}^H(z) - \Delta a_{kt}^F(z)$ is the difference in the changes of deterministic components of nontradable productivities; $\alpha_{kt-1}^H(z)$ and $\alpha_{kt-1}^F(z)$ are the cyclical components of nontradable productivities in country k and its base country, respectively. (3) The top row indicates the frequency of the data. (4) The numbers in the parentheses are clustered standard errors that are robust to heteroskedasticity across countries and serial correlation in error terms. (5) All regressions include country fixed effects. (6) *, **, and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively.

Table 6: Real wage regressions

	Annual	Annual	Quadrennial	Quadrennial
	(1)	(2)	(3)	(4)
$\Delta ln(real\ W_{kt}^F)$	-.45 (0.38)	-.60 (0.33)*	-.70 (0.56)	-.64 (0.64)
$peg_{kt} \times \Delta ln(real\ W_{kt}^F)$	-.28 (0.36)		-.48 (0.44)	
peg_{kt}	-.01 (0.03)		-.08 (0.09)	
$EMU_{kt} \times \Delta ln(real\ W_{kt}^F)$		0.26 (0.47)		-3.15 (3.17)
EMU_{kt}		0.02 (0.04)		0.12 (0.22)
$trade_{kt} \times \Delta ln(real\ W_{kt}^F)$	0.16 (0.05)***	0.15 (0.07)**	0.23 (0.10)**	0.20 (0.10)**
$trade_{kt}$	0.009 (0.01)	0.008 (0.02)	0.08 (0.10)	0.06 (0.05)
$FDI_{kt} \times \Delta ln(real\ W_{kt}^F)$	0.004 (0.04)	-.002 (0.05)	0.45 (1.04)	0.85 (1.53)
FDI_{kt}	-.001 (0.003)	-.001 (0.003)	0.01 (0.06)	0.03 (0.08)
$migration_{kt} \times \Delta ln(real\ W_{kt}^F)$	0.003 (0.002)	0.002 (0.002)	-.002 (0.008)	0.003 (0.04)
$migration_{kt}$	-.000 (0.001)	-.000 (0.001)	-.002 (0.002)	-.001 (0.003)
$\Delta ln(e_{kt})$	0.15 (0.16)	0.26 (0.16)	1.11 (0.47)**	1.11 (0.34)***
$\Delta ln(D_{kt})$	-.16 (0.15)	-.23 (0.16)	-1.42 (0.62)**	-1.27 (0.47)***
$\Delta ln(P_{kt}^H) - \Delta ln(P_{kt}^F)$	-.92 (0.5)*	-1.02 (0.55)*	-1.98 (1.06)*	-1.99 (0.35)***
$\Delta a_{kt}^H(z) - \Delta a_{kt}^F(z)$	-.13 (0.09)	-.15 (0.12)	-.58 (0.49)	-.65 (0.39)*
$\alpha_{kt-1}^H(z)$	-.51 (0.16)***	-.49 (0.19)***	-7.14 (6.33)	-6.50 (4.53)
$\alpha_{kt-1}^F(z)$	-.31 (0.24)	-.28 (0.24)	4.91 (8.26)	6.62 (8.28)
Obs.	1163	1008	290	261
R^2	0.23	0.24	0.34	0.34

Notes: (1) The dependent variable is the real wage growth rate of country k. (2) $\Delta\ ln(real\ W_{kt}^F)$ is the real wage growth rate of the base country; peg_{kt} equals 1 if country k pegs its currency to that of its base country via a currency union or other arrangements, and 0 otherwise; EMU_{kt} equals 1 if both country k and its base country are members of the EMU, and 0 otherwise; $trade_{kt}$ is a measure for trade intensity between country k and its base country; FDI_{kt} and $migration_{kt}$ are measures for bilateral FDI and migration, respectively; e_{kt} is the bilateral nominal exchange rate; D_{kt} is the ratio of the CPI of tradable goods in country k's base country to its counterpart in country k; P_{kt}^H and P_{kt}^F are country k's CPI and its base country's CPI, respectively; $\Delta a_{kt}^H(z) - \Delta a_{kt}^F(z)$ is the difference in the changes of deterministic components of nontradable productivities; $\alpha_{kt-1}^H(z)$ and $\alpha_{kt-1}^F(z)$ are the cyclical components of nontradable productivities in country k and its base country, respectively. (3) The top row indicates the frequency of the data. (4) The numbers in the parentheses are clustered standard errors that are robust to heteroskedasticity across countries and serial correlation in error terms. (5) All regressions include country fixed effects. (6) *, **, and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively.