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Exchange Rate Regimes and Nominal Wage Comovements in a Dynamic Ricardian Model

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Exchange Rate Regimes and Nominal Wage Comovements in a Dynamic Ricardian Model*

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Abstract

We construct a dynamic Ricardian model of trade with money and nominal exchange rate. The model implies that the nominal wages of the trading countries are more likely to exhibit stronger positive comovements when the countries fix their bilateral exchange rates. Panel regression results based on data from OECD countries from 1973 to 2012 suggest that countries in the European Monetary Union (EMU) experienced stronger positive wage comovements with their main trade partners. When we restrict the regression to the subsample of the EMU countries, we find a significant increase in wage comovements after these countries joined the EMU in 1999 compared to the pre-euro era. In comparison, when the sample is restricted to the non-EMU countries, we find no evidence that non-currency union pegs affected the wage comovements.

JEL classification: F1, F3
Keywords: fixed exchange rate regime, currency union, trade, wage comovements

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1 Introduction

Nominal wages and exchange rates are important factors in international trade. However, typical Ricardian models of trade are real models and thus do not explicitly deal with the monetary aspects of trade such as changes in nominal wage and exchange rate, albeit Dornbusch et al. (1977) and Ito and Ohyama (1985) point out that it is possible to extend the discussion of the standard Ricardian model to include these nominal variables. Thus in this paper, we construct a dynamic Ricardian model with money and nominal exchange rate. We borrow the elements of a Ricardian trade model and market structure from Dornbusch et al. (1977), Eaton and Kortum (2002), and Levchenko and Zhang (2011), and the elements of money and exchange rate from Chari et al. (2002).

From our model, we obtain an interesting theoretical prediction regarding the effects of exchange rate regimes and trade on the comovements of nominal wages: if a country fixes the exchange rate with its main trade partner, then its wage will comove strongly and positively with its partner's wage.[1] Intuitively, a fixed exchange rate implies that the two countries have similar growth rates in money supplies that then lead to similar growth rates in nominal wages. However, if a country floats the exchange rate, then its wage does not necessarily comove with that of its main trade partner, as the exchange rate can adjust to maintain the relative wages and prices. Thus the model predicts stronger comovements of wages between countries that fix their bilateral exchange rates.

In practice, many countries adopt fixed exchange rate regimes, with the extreme case being a currency union. In the 1990s, among the 91 economies studied by Sterne (1999), the number of countries adopting an explicit exchange rate target increased from 30 to 47. In 1999, the creation of the European Monetary Union (EMU) locked in 11 European countries committed to a single currency, and the EMU has been expanding

[1] Our interests are in the comovements of nominal wages, so in the following discussion the word "wage(s)" refers to nominal wage(s), unless otherwise noted.

since. However, in the wake of recent crises in peripheral countries in the EMU, economic commentators (for instance Economist, 2010) suggest that relative to Germany, countries such as Greece and Ireland have wages that are too high for their products to be competitive internationally. Yet, as EMU members, they do not have the option of devaluation to promote their products. Such observations suggest that for countries in a currency union and countries adopting currency pegs, whether their wages align with those of their main trade partners has important economic consequences.

To the best of our knowledge, however, no previous studies have examined theoretically or empirically the effects of exchange rate regimes and trade on wage comovements between countries. Our paper now fills this void by constructing a model of exchange rate, trade, and wage comovements, and by testing the model's central prediction that wages comove strongly and positively between trading countries that peg their currencies. The results of panel regressions based on data from 24 OECD countries from 1973 to 2012 suggest that if a country and its main trade partner were in the EMU, then their wages experienced stronger comovements. We also run regressions with the sample restricted to EMU countries to determine whether joining the EMU in 1999 was associated with stronger positive wage comovements. We find that for EMU countries, there was a significant increase in wage comovements after joining the EMU, compared to the pre-euro era. Meanwhile, for the non-EMU countries, there is no evidence that non-currency-union pegs strengthened the positive wage comovements.

Our paper thus makes the following contributions to the trade and wage literature, the exchange rate and wage literature, the nominal wage comovement literature, and the nominal anchor literature. First, our paper adds to the large literature on the wage effects of trade. The well-known factor price equalization theorem of the Heckscher-Ohlin (H-O) model of trade claims that through the convergence of the relative prices of goods, trade causes the convergence of the relative prices of labor and capital between the trading countries.[2] Many studies also analyze the effects of trade on the relative wage of skilled and unskilled labor. While the Stolper-Samuelson theorem of the H-O model claims that trade causes the relative wage to increase in a skill-abundant country but decrease in a skill-scarce country, some studies such as Feenstra and Hanson (1996), Acemoglu (2003), and Kurokawa (2011) claim that trade can cause the relative wage to increase in both of the trading countries.[3] These arguments use real models of trade to analyze the wage effects of trade. However, by incorporating money and exchange rate into the Ricardian model, our paper reveals that the effects of trade on the nominal wage comovements between the trading countries are different under the fixed and floating 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 also adds to the literature on the relationship between exchange rates and wages. While many studies have linked real exchange rates to real wages (e.g. Goldberg and Tracy 2000; Campa and Goldberg 2001), our paper now links nominal exchange rates to nominal wages and provides new theoretical and empirical insights regarding the relationship between exchange rates and wages.

Third, our results also add to the knowledge of nominal wage comovements. Many previous studies analyze the comovements of macro variables. For example, there is a large literature on the comovements between exchange rates and other macro variables (e.g. Stockman, 1987; Baxter and Stockman, 1989; Flood and Rose, 1995; Obstfeld and Rogoff, 1995a; Stockman, 1998; Kollmann, 2001; Chari et al., 2002; Duarte et al., 2007). Surprisingly, however, there are few studies that analyze the comovements of nominal wages. In fact, as far as we are aware, there are only three studies on the subject. The first, Budd

[2]See Samuelson (1948) and Lerner (1952) for a proof of the theorem.

[3]For example, see Feenstra and Hanson (2003), Kremer and Maskin (2006), Goldberg and Pavcnik (2007), Chusseau et al. (2008), Harrison et al. (2012), and Kurokawa (2012) for a survey on trade and wage inequality.

et al. (2002), highlights the comovements of nominal wages within a multinational. They show the existence of comovements of nominal wages within a multinational firm through internal risk sharing. The second, Robertson (2000), highlights the comovements of nominal wages between the interior and border regions in a country. He provides evidence for these comovements between the interior and border regions of Mexico, thus indicating that the wage impact of emigration is transmitted to the overall Mexican economy. The third, Lamo, Perez and Schuknecht (2008), highlights the comovements of nominal wages across sectors within a country. They show strong positive 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.[4] 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 highlight that for countries that engage extensively in trade, the choice of a fixed exchange rate regime will enhance nominal wage comovements between countries.

Fourth, our results also add to the knowledge of how an exchange rate peg acts as a nominal anchor. A currency peg or membership of a monetary union is one way to provide a nominal anchor for a country's output prices or inflation rate (Edwards, 1993; Calvo and Vegh, 1994; Willett, 1998). Our results suggest that in addition to providing a nominal anchor for output prices or the inflation rate, a monetary union can provide a nominal anchor for wages.

The rest of this paper is organized as follows. In Section 2, we construct a dynamic Ricardian model with money and nominal exchange rate 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.

[4]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 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 (mainly Sweden plus a few others).

2 Theory

In this section, we construct a dynamic Ricardian model of trade with money and nominal exchange rate and thus address the monetary aspects of trade. The setup of the model borrows from two main sources, first, the Ricardian models (Dornbusch et al., 1977; Eaton and Kortum, 2002; Levchenko and Zhang, 2011), 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 analytic solutions, and 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 foreign country are indicated by a superscript $*$. Each country is capable of producing the same continuum of traded goods. The traded goods are indexed by i, and $i \in [0, 1]$. Each country also produces a non-traded good, respectively.

The period preference for home country's representative consumer is (note that the time subscript t is suppressed, wherever possible)

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

where

$$C_t = \left[(\int_0^1 C_{it}^{\frac{\eta-1}{\eta}} di)^{\epsilon \cdot \frac{\eta}{\eta-1}} \cdot C_{zt}^{1-\epsilon} \right],$$

and ζ, χ, κ and $\gamma > 0$. The period budget constraint is

$$\int_0^1 P_{it} C_{it} di + P_{zt} C_{zt} + M_t + \sum_s q_{t+1}(s_{t+1}) B_{t+1}(s_{t+1}) = W_t L_t + M_{t-1} + B_t + \Pi_t + T_t.$$

Here, C_i denotes the consumption of traded good i in the home country, C_z is the consumption of the non-traded good in the home country. The quantity L is labor in the home country. The variables M and P are money supply and the aggregate price level. The variables P_i, P_z, and W are the nominal price of traded good i, the nominal price of non-traded good, and nominal wage. The variables $q_{t+1}(s_{t+1})$ and $B_{t+1}(s_{t+1})$ are the price and the quantity of a nominal bond that pays one unit of home currency in state s in period $t+1$, and zero otherwise. Lastly, Π and T are profits of home firms and a nominal transfer from the home government. Because our focus is on wages, we drop physical capital for the basic model, as in Eaton and Kortum (2002).

Given the prices P_{it} and P_{zt}, the minimization of the cost of C_t yields the following unit cost of C_t, which we refer to as the price of C_t

$$P_t = [\epsilon^{-\epsilon}(1-\epsilon)^{\epsilon-1}](\int_0^1 P_{it}^{1-\eta} di)^{\frac{1}{1-\eta}\epsilon}(P_{zt})^{1-\epsilon}. \tag{1}$$

Hence, the budget constraint can be written as

$$P_t C_t + M_t + \sum_s q_{t+1}(s_{t+1}) B_{t+1}(s_{t+1}) = W_t L_t + M_{t-1} + B_t + \Pi_t + T_t. \tag{2}$$

The production technology in the home country is

$$Y_{it} = A_{it} L_{it}, \tag{3}$$

$$Y_{zt} = A_{zt} L_{zt}, \tag{4}$$

where A_{it} and A_{zt} are the stochastic productivities. The market for each traded good is perfectly competitive. The home producers of good i will have to compete with the foreign producer of firm i. Home and foreign consumers only buy from the producers with the lowest price, and there is no shipping cost.

Given the linear production technology and perfect competition, the local-currency prices charged by home and foreign producers of good i are

$$P_{it}^{H} = W_t / A_{it}, \tag{5}$$

$$P_{it}^{F} = W_t^* / A_{it}^*. \tag{6}$$

The prevailing home price for good i is

$$P_{it} = \min\left\{P_{it}^{H}, P_{it}^{F} e_t\right\},$$

where e_t is the nominal exchange rate, defined as the price of foreign currency in home currency. We order the varieties i such that A_{it}/A_{it}^* is decreasing in i. As in Dornbusch et al. (1977), we assume that A_{it}/A_{it}^* is strictly decreasing in i. Let $k \in [0, 1]$ be the cutoff variety for which $P_{kt}^{H} = e_t P_{kt}^{F}$. Then the home country will produce all varieties with indices $i < k$, and the foreign country will produce all variety with $i > k$. We assume that both countries produce good k and there is no international trade of the variety k. The market for non-traded goods is also perfectly competitive. Consequently, the local-currency prices for the nontraded goods are

$$P_{zt} = W_t / A_{zt}, \tag{7}$$

$$P_{zt}^* = W_t^* / A_{zt}^*. \tag{8}$$

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 later subsections for different exchange rate regimes. Any new money balance $M_t - M_{t-1}$ is distributed to households through lumpsum transfer. That is, $T_t = M_t - M_{t-1}$. The real exchange rate is determined by the ratio of home and foreign marginal utility of consumption, see equation

(14) of Chari et al. (2002). Unlike Chari et al. (2002), our focus is not on nominal price rigidity. Hence, we assume flexible prices.

At the beginning of each period, both money shocks and productivity shocks are observed by all players in the economy. Then firms post prices, consumers make purchase decisions, production occurs, and markets clear.

The market clearing conditions are

$$\int_0^k L_{it} di + L_{zt} = L_t, \tag{9}$$

$$\int_k^1 L_{it}^* di + L_{zt}^* = L_t^*, \tag{10}$$

$$Y_{it} = C_{it} + C_{it}^* \quad \forall i < k, \tag{11}$$

$$Y_{it}^* = C_{it} + C_{it}^* \quad \forall i > k, \tag{12}$$

$$Y_{zt} = C_{zt}, Y_{zt}^* = C_{zt}^*. \tag{13}$$

In addition, there is a balanced-trade condition

$$\int_0^k C_{it}^* P_{it} di = \int_k^1 C_{it} P_{it} di. \tag{14}$$

2.2 Characterizing the solution

For the household's maximization problem, the first order conditions with respect to C_{it}, C_{zt}, L_t, M_t, and $B_{t+1}(s)$ are

$$C_t^{1-\zeta} \frac{\epsilon (C_{it})^{\frac{-1}{\eta}}}{\int_0^1 (C_{it})^{\frac{\eta-1}{\eta}} di} = P_{it}\lambda_t, \tag{15}$$

$$C_t^{1-\zeta} \frac{1-\epsilon}{C_{zt}} = P_{zt}\lambda_t, \tag{16}$$

$$\kappa L_t^{\gamma} = W_t \lambda_t, \tag{17}$$

$$\frac{\chi h'(M_t/P_t)}{P_t} = \lambda_t - \beta E_t \lambda_{t+1}, \tag{18}$$

$$\beta E_t \lambda_{t+1}(s_{t+1}) = q_{t+1}(s_{t+1}) \cdot \lambda_t. \tag{19}$$

An equivalent approach is to maximize the household's utility with respect to equation (2). The first order condition with respect to the aggregate consumption C_t is

$$C_t^{-\zeta} = P_t \lambda_t, \tag{20}$$

while other first order conditions are identical.

To determine the equilibrium exchange rate, we follow the argument of Chari et al. (2002). First, we use the s_t notation and rewrite equations (20) and (19) to explicitly recognize the evolution of states:

$$\lambda(s_t) = \frac{U_c(s_t)}{P(s_t)}, \tag{21}$$

$$\beta \pi(s_t | s_{t-1}) \lambda(s_t) = q(s_t | s_{t-1}) \lambda(s_{t-1}). \tag{22}$$

Substituting equation (21) into (22), we have

$$q(s_t|s_{t-1}) = \beta\pi(s_t|s_{t-1})\frac{U_c(s_t)}{P(s_t)}\frac{P(s_{t-1})}{U_c(s_{t-1})}. \tag{23}$$

Because the payments of the set of home nominal bonds are state contingent, adding foreign nominal bonds will not add to the structure of financial market. Therefore, the foreign household will be happy to buy just the home bonds. For the foreign household, the pricing of the home nominal bonds must satisfy

$$q(s_t|s_{t-1}) = \beta\pi(s_t|s_{t-1})\frac{U_c^*(s_t)}{P^*(s_t)e(s_t)}\frac{P^*(s_{t-1})e(s_{t-1})}{U_c^*(s_{t-1})}. \tag{24}$$

Combining equations (23) and (24) yields

$$\frac{P(s_t)}{U_c(s_t)} = \frac{P^*(s_t)}{U_c^*(s_t)}\frac{U_c^*(s_{t-1})}{P^*(s_{t-1})}\frac{e(s_t)}{e_(s_{t-1})}\frac{P(s_{t-1})}{U_c(s_{t-1})}. \tag{25}$$

Bringing equation (25) back one period and substituting it into (25) to eliminate $\frac{U_c(s_{t-1})}{P(s_{t-1})}$, we get

$$\frac{P(s_t)}{U_c(s_t)} = \frac{P^*(s_t)}{U_c^*(s_t)}\frac{U_c^*(s_{t-2})}{P^*(s_{t-2})}\frac{e(s_t)}{e_(s_{t-2})}\frac{P(s_{t-2})}{U_c(s_{t-2})}.$$

Iterative substitution yields

$$e(s_t) = \frac{P(s_t)}{U_c(s_t)}\frac{U_c^*(s_t)}{P^*(s_t)}e(s_0)\frac{U_c(s_0)}{U_c^*(s_0)}\frac{P^*(s_0)}{P(s_0)}.$$

Defining the constant δ as

$$\delta = e(s_0)\frac{U_c(s_0)}{U_c^*(s_0)}\frac{P^*(s_0)}{P(s_0)}, \tag{26}$$

and dropping the s_t notation, we have the expression for equilibrium nominal exchange rate

$$e_t = \frac{P_t}{U_{ct}} \frac{U^*_{ct}}{P^*_t} \delta. \tag{27}$$

Substituting the marginal utility of C_t implied by the utility function into (27), we have

$$e_t = \frac{P_t C_t^{\zeta}}{P^*_t (C^*_t)^{\zeta}} \delta. \tag{28}$$

Note that we can use (20) to rewrite the last equation as

$$e_t = \frac{\lambda^*_t}{\lambda_t} \delta, \tag{29}$$

which states that the exchange rate is equal to the ratio of marginal utility of nominal wealth in the two countries.

Next, we state two lemmas useful for the proof of Proposition 1 that gives the general relationship between growth in home and foreign nominal wages.

Lemma 1. *Labor and consumption are linked by the equation* $L_t = \kappa^{\frac{-1}{1+\gamma}} C_t^{\frac{1-\zeta}{1+\gamma}}$.

Proof: Note that equations (4), (13), (7), and (17) imply

$$\begin{aligned} C_{zt} &= L_{zt} A_{zt}, \\ P_{zt} &= \frac{W_t}{A_{zt}}, \\ \lambda_t &= \frac{\kappa L_t^{\gamma}}{W_t}. \end{aligned}$$

Using these equations to eliminate C_{zt}, P_{zt}, and λ_t from equation (16), we have

$$(1-\epsilon)C_t^{1-\zeta} = L_{zt}L_t^{\gamma}\kappa. \tag{30}$$

Rewrite (15) as

$$C_t^{1-\zeta}\frac{\epsilon(C_{it})^{\frac{\eta-1}{\eta}}}{\int_0^1 (C_{it})^{\frac{\eta-1}{\eta}}di} = C_{it}P_{it}\lambda_t.$$

Integrating both sides with respect to i, we have

$$\begin{aligned}\int_0^1 C_{it}P_{it}di &= \frac{\epsilon}{\lambda_t}C_t^{1-\zeta} \Rightarrow \\ \int_0^k C_{it}P_{it}di + \int_k^1 C_{it}P_{it}di &= \frac{\epsilon}{\lambda_t}C_t^{1-\zeta}.\end{aligned}$$

Substituting the balanced trade condition into the above, we have

$$\begin{aligned}\int_0^k C_{it}P_{it}di + \int_0^k C_{it}^{*}P_{it}di &= \frac{\epsilon}{\lambda_t}C_t^{1-\zeta} \Rightarrow \\ \int_0^k (C_{it}+C_{it}^{*})P_{it}di &= \frac{\epsilon}{\lambda_t}C_t^{1-\zeta}.\end{aligned} \tag{31}$$

Note that equations (5), (3), and (11) imply

$$\begin{aligned}C_{it}+C_{it}^{*} &= L_{it}A_{it}, \\ P_{it} &= \frac{W_t}{A_{it}} \quad \forall\ i<k.\end{aligned}$$

Substituting these equations into equation (31), we obtain

$$\int_0^k L_{it}di = \frac{\epsilon}{W_t\lambda_t}C_t^{1-\zeta}. \tag{32}$$

Similarly, combining equations (4), (13), (7), (16) and (17), we can obtain

$$L_{zt} = \frac{1-\epsilon}{W_t \lambda_t} C_t^{1-\zeta}. \tag{33}$$

Combining (32) and (33) yields

$$\frac{\int_0^k L_{it} di}{L_{zt}} = \frac{\epsilon}{1-\epsilon}. \tag{34}$$

Using equation (34) to eliminate $\int_0^k L_{it} di$ from equation (9), we have

$$L_{zt} = (1-\epsilon)L_t.$$

Substituting the last line into equation (30), we can obtain

$$\begin{aligned} C_t^{1-\zeta} &= \kappa L_t^{1+\gamma} \Rightarrow \\ L_t &= \kappa^{\frac{-1}{1+\gamma}} C_t^{\frac{1-\zeta}{1+\gamma}}. \end{aligned} \tag{35}$$

■

Lemma 2. *The real exchange rate is*

$$e_t \frac{P_t^*}{P_t} = e_t^{1-\epsilon} (\frac{W_t^* A_{zt}}{W_t A_{zt}^*})^{1-\epsilon}. \tag{36}$$

Proof: Substituting equation (1) into the definition of real exchange rate, we have

$$e_t \frac{P_t^*}{P_t} = e_t \frac{[\epsilon^{-\epsilon}(1-\epsilon)^{\epsilon-1}](\int_0^1 (P_{it}^*)^{1-\eta} di)^{\frac{1}{1-\eta}\epsilon} (P_{zt}^*)^{1-\epsilon}}{[\epsilon^{-\epsilon}(1-\epsilon)^{\epsilon-1}](\int_0^1 P_{it}^{1-\eta} di)^{\frac{1}{1-\eta}\epsilon} (P_{zt})^{1-\epsilon}}.$$

Note that the price of traded good i in the foreign currency is

$$P_{it}^* = P_{it}/e_t \ \forall i,$$

and the local-currency prices of nontraded goods are

$$\begin{aligned} P_{zt} &= \frac{W_t}{A_{zt}}, \\ P_{zt}^* &= \frac{W_t^*}{A_{zt}^*}. \end{aligned}$$

The expression for the real exchange rate becomes

$$\begin{aligned} e_t \frac{P_t^*}{P_t} &= e_t \frac{(\int_0^1 (P_{it}^*)^{1-\eta} di)^{\frac{1}{1-\eta}\epsilon} (\frac{W_t^*}{A_{zt}^*})^{1-\epsilon}}{(\int_0^1 (P_{it}^* e_t)^{1-\eta} di)^{\frac{1}{1-\eta}\epsilon} (\frac{W_t}{A_{zt}})^{1-\epsilon}} \\ &= e_t^{1-\epsilon} (\frac{W_t^* A_{zt}}{W_t A_{zt}^*})^{1-\epsilon}. \end{aligned}$$

■

Next, using (28) and Lemmas 1 and 2, we obtain an equation regarding L_t/L_{t-1}. Rewrite (28) as

$$\frac{C_t}{C_t^*} = [\frac{1}{\delta} e_t \frac{P_t^*}{P_t}]^{1/\zeta}.$$

Substituting (36) into the above, we have

$$\begin{aligned} \frac{C_t}{C_t^*} &= \left\{ \frac{1}{\delta} e_t^{1-\epsilon} (\frac{W_t^* A_{zt}}{W_t A_{zt}^*})^{1-\epsilon} \right\}^{1/\zeta} \\ &= \frac{1}{\delta^{1/\zeta}} e_t^{\frac{1-\epsilon}{\zeta}} (\frac{W_t^* A_{zt}}{W_t A_{zt}^*})^{\frac{1-\epsilon}{\zeta}}. \end{aligned} \tag{37}$$

Dividing the last equation by its counterpart in period $t-1$ yields

$$\frac{C_t}{C_{t-1}} = \frac{C_t^*}{C_{t-1}^*}(\frac{e_t}{e_{t-1}})^{\frac{1-\epsilon}{\zeta}}(\frac{W_t^* W_{t-1}}{W_{t-1}^* W_t})^{\frac{1-\epsilon}{\zeta}}(\frac{A_{zt}A_{zt-1}^*}{A_{zt-1}A_{zt}^*})^{\frac{1-\epsilon}{\zeta}}. \tag{38}$$

Note that equation (35) implies that the labor growth is

$$\frac{L_t}{L_{t-1}} = (\frac{C_t}{C_{t-1}})^{\frac{1-\zeta}{1+\gamma}}.$$

Substituting equation (38) into the last line, we have

$$\frac{L_t}{L_{t-1}} = (\frac{C_t^*}{C_{t-1}^*})^{\frac{1-\zeta}{1+\gamma}}(\frac{e_t}{e_{t-1}})^{\frac{1-\epsilon}{\zeta}\frac{1-\zeta}{1+\gamma}}(\frac{W_t^* W_{t-1}}{W_{t-1}^* W_t})^{\frac{1-\epsilon}{\zeta}\frac{1-\zeta}{1+\gamma}}(\frac{A_{zt}A_{zt-1}^*}{A_{zt-1}A_{zt}^*})^{\frac{1-\epsilon}{\zeta}\frac{1-\zeta}{1+\gamma}}. \tag{39}$$

We now derive Proposition 1 regarding the relationship between the home and foreign nominal wage movements.

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

$$\frac{W_t}{W_{t-1}} = \frac{W_t^*}{W_{t-1}^*}\frac{e_t}{e_{t-1}}(\frac{A_{zt}A_{zt-1}^*}{A_{zt-1}A_{zt}^*})^{\frac{\gamma(1-\epsilon)(1-\zeta)}{\gamma(1-\epsilon)+\zeta(1+\gamma\epsilon)}}. \tag{40}$$

Proof: The FOC for labor supply (17) implies

$$\frac{W_t^*}{W_{t-1}^*} = (\frac{L_t^*}{L_{t-1}^*})^{\gamma}\frac{\lambda_{t-1}^*}{\lambda_t^*}, \tag{41}$$

and

$$\frac{W_t}{W_t^*} = \frac{\kappa L_t^{\gamma}/\lambda_t}{\kappa (L_t^*)^{\gamma}/\lambda_t^*}.$$

Using equation (29) to eliminate λ_t and λ_t^* from the last line, we have

$$\frac{W_t}{W_t^*} = (\frac{L_t}{L_t^*})^{\gamma}\frac{e_t}{\delta}. \tag{42}$$

Dividing the last equation by its counterpart in period $t-1$ yields

$$\begin{aligned}\frac{W_t}{W_{t-1}} &= \frac{W_t^*}{W_{t-1}^*}(\frac{L_t}{L_{t-1}})^{\gamma}(\frac{L_{t-1}^*}{L_t^*})^{\gamma}\frac{e_t}{e_{t-1}} \\ &= (\frac{L_t}{L_{t-1}})^{\gamma}\frac{\lambda_{t-1}^*}{\lambda_t^*}\frac{e_t}{e_{t-1}},\end{aligned} \tag{43}$$

where the last equality follows from equation (41). Substituting equation (39) into the last line, we obtain

$$\begin{aligned}\frac{W_t}{W_{t-1}} = (\frac{C_t^*}{C_{t-1}^*})^{\gamma(\frac{1-\zeta}{1+\gamma})}(\frac{e_t}{e_{t-1}})^{\frac{\gamma(1-\epsilon)(1-\zeta)}{\zeta(1+\gamma)}+1}(\frac{W_t^* W_{t-1}}{W_{t-1}^* W_t})^{\frac{\gamma(1-\epsilon)(1-\zeta)}{\zeta(1+\gamma)}} \\ \cdot (\frac{A_{zt}A_{zt-1}^*}{A_{zt-1}A_{zt}^*})^{\frac{\gamma(1-\epsilon)(1-\zeta)}{\zeta(1+\gamma)}}\frac{\lambda_{t-1}^*}{\lambda_t^*}.\end{aligned} \tag{44}$$

Using equation (35) to eliminate L_t^* and L_{t-1}^* from equation (41), we have

$$\frac{W_t^*}{W_{t-1}^*} = (\frac{C_t^*}{C_{t-1}^*})^{\frac{\gamma(1-\zeta)}{1+\gamma}}\frac{\lambda_{t-1}^*}{\lambda_t^*}. \tag{45}$$

Dividing equation (44) by equation (45), we obtain

$$\begin{aligned}\frac{W_t}{W_{t-1}}\frac{W_{t-1}^*}{W_t^*} &= (\frac{e_t}{e_{t-1}})^{\frac{\gamma(1-\epsilon)(1-\zeta)}{\zeta(1+\gamma)}+1}(\frac{W_t^* W_{t-1}}{W_{t-1}^* W_t})^{\frac{\gamma(1-\epsilon)(1-\zeta)}{\zeta(1+\gamma)}} \\ &\quad \cdot (\frac{A_{zt}A_{zt-1}^*}{A_{zt-1}A_{zt}^*})^{\frac{\gamma(1-\epsilon)(1-\zeta)}{\zeta(1+\gamma)}} \Rightarrow \\ (\frac{W_t}{W_{t-1}})^{\frac{\gamma(1-\epsilon)(1-\zeta)}{\zeta(1+\gamma)}+1} &= (\frac{e_t}{e_{t-1}})^{\frac{\gamma(1-\epsilon)(1-\zeta)}{\zeta(1+\gamma)}+1}(\frac{W_t^*}{W_{t-1}^*})^{\frac{\gamma(1-\epsilon)(1-\zeta)}{\zeta(1+\gamma)}+1} \\ &\quad \cdot (\frac{A_{zt}A_{zt-1}^*}{A_{zt-1}A_{zt}^*})^{\frac{\gamma(1-\epsilon)(1-\zeta)}{\zeta(1+\gamma)}} \Rightarrow\end{aligned}$$

$$\frac{W_t}{W_{t-1}} = \frac{W_t^*}{W_{t-1}^*} \frac{e_t}{e_{t-1}} (\frac{A_{zt} A_{zt-1}^*}{A_{zt-1} A_{zt}^*})^{\frac{\gamma(1-\epsilon)(1-\zeta)}{\gamma(1-\epsilon)+\zeta(1+\gamma\epsilon)}}.$$

■

The relationship between the home and foreign nominal wage movements obtained in Proposition 1 is quite general, because we do not need any assumption on the functional form of the utility from real balance, on the stochastic processes of productivities, or on the stochastic processes of money supplies. Based on Proposition 1, we make three observations. First, if the exchange rate is fixed, then the home wage growth is equal to foreign wage growth multiplied by a positive stochastic random variable, which is a function of the relative productivity growth in the nontraded goods, $(A_{zt}/A_{zt-1})/(A_{zt}^*/A_{zt-1}^*)$.

Second, if $\zeta > 1$, then the fraction

$$\frac{\gamma(1-\epsilon)(1-\zeta)}{\gamma(1-\epsilon)+\zeta(1+\gamma\epsilon)} \tag{46}$$

is negative. When the exchange rate is fixed, the sign of the fraction implies that if the home productivity growth in nontraded goods is faster than the foreign, then growth in home wage will be lower than the foreign wage growth.

Third, if $\zeta = 1$, i.e. the utility with respect to consumption has log form, then equation (40) is reduced to

$$\frac{W_t}{W_{t-1}} = \frac{W_t^*}{W_{t-1}^*} \frac{e_t}{e_{t-1}}.$$

In this case, when the exchange rate is fixed, the comovements between home and foreign wages are perfect.

2.3 Wage comovements

In the previous subsection, we have derived the relationship between the home and foreign nominal wage movements. In this subsection, we explicitly show that wage comovements are stronger under the fixed exchange rate regime, by further assuming that utility of real balance and productivities are given by

- (a) $h(M_t/P_t) = ln(M_t/P_t)$.
- (b) the productivities are

$$A_{it} = A_i exp(a(t) + u_t),$$

$$A_{zt} = A_z exp(a_z(t) + v_t),$$

$$A^*_{it} = A^*_i exp(a^*(t) + u^*_t),$$

$$A^*_{zt} = A^*_z exp(a^*_z(t) + v^*_t),$$

  where $a(t), a_z(t), a^*(t)$, and $a^*_z(t)$ are deterministic functions of time that describe the trends in productivities. The variables u_t, v_t, u^*_t and v^*_t are iid shocks with zero means.

  Regarding the money supplies, we assume that

- (c1) when the exchange rate is flexible, the home and foreign money supplies follow the stochastic process

$$M_t = exp(\mu_t) M_{t-1}(1 + g), \tag{47}$$

$$M^*_t = exp(\mu^*_t) M^*_{t-1}(1 + g^*), \tag{48}$$

  where g and g^* are constants, and μ_t and μ^*_t are zero-mean iid shocks with a common cdf $\Phi(\mu)$.

- (c2) if the exchange rate is fixed, the foreign money supplies follow the stochastic process

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

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

Under assumptions (a) and (c1), we first solve for the marginal utilities of nominal wealth λ_t, and λ_t^*, before deriving the results on wage comovements.

Lemma 3. *Under assumptions (a) and (c1), the marginal utilities of nominal wealth λ_t, and λ_t^* are*

$$\lambda_t = \frac{\chi\psi}{M_t}, \tag{49}$$

$$\lambda_t^* = \frac{\chi\psi^*}{M_t^*}, \tag{50}$$

where ψ and ψ^* are constants.

Proof: From the foreign version of equation (18), we have

$$
\begin{aligned}
\lambda_t^* &= \frac{\chi}{M_t^*} + \beta E_t \lambda_{t+1}^* \\
&= \frac{\chi}{M_t^*} + \beta E_t(\frac{\chi}{M_{t+1}^*} + \beta E_{t+1}\lambda_{t+2}^*) \\
&= \frac{\chi}{M_t^*} + \beta E_t(\frac{\chi}{M_{t+1}^*}) + \beta^2 E_t(\frac{\chi}{M_{t+2}^*}) + \beta^3 E_t(\frac{\chi}{M_{t+3}^*}) + \cdots \\
&= \frac{\chi}{M_t^*} + \beta E_t(\frac{\chi}{M_t^* exp(\mu_{t+1}^*)(1+g^*)}) + \beta^2 E_t(\frac{\chi}{M_t^* exp(\mu_{t+1}^*) exp(\mu_{t+2}^*)(1+g^*)^2}) + \\
&\quad \beta^3 E_t(\frac{\chi}{M_t^* exp(\mu_{t+1}^*) exp(\mu_{t+2}^*) exp(\mu_{t+3}^*)(1+g^*)^3}) + \cdots \\
&= \frac{\chi}{M_t^*}\left[1 + \frac{\beta}{1+g^*} E_t(\frac{1}{exp(\mu_{t+1}^*)}) + (\frac{\beta}{1+g^*})^2 E_t(\frac{1}{exp(\mu_{t+1}^*) exp(\mu_{t+2}^*)}) \right. \\
&\quad \left. +(\frac{\beta}{1+g^*})^3 E_t(\frac{1}{exp(\mu_{t+1}^*) exp(\mu_{t+2}^*) exp(\mu_{t+3}^*)}) + \cdots \right] \\
&= \frac{\chi}{M_t^*}\left[1 + \frac{\beta}{1+g^*}\int \frac{1}{exp(\mu^*)} d\Phi(\mu^*) + (\frac{\beta}{1+g^*})^2 \int\int \frac{1}{exp(\mu^*)} d\Phi(\mu^*) \frac{1}{exp(\mu^*)} d\Phi(\mu^*) \right. \\
&\quad \left. + (\frac{\beta}{1+g^*})^3 \int\int\int \frac{1}{exp(\mu^*)} d\Phi(\mu^*) \frac{1}{exp(\mu^*)} d\Phi(\mu^*) \frac{1}{exp(\mu^*)} d\Phi(\mu^*) + \cdots \right].
\end{aligned}
$$

The terms in the brackets are equal to a constant. Defining the constant as ψ^*, we have

$$\lambda_t^* = \frac{\chi\psi^*}{M_t^*} = \frac{\chi\psi^*}{M_{t-1}^* exp(\mu_t^*)(1+g^*)}.$$

The expression for λ_t can be obtained similarly. ■

Combined with equation (29), an immediate corollary of Lemma 3 is that

$$e_t = \frac{M_t}{M_t^*}\frac{\delta\psi^*}{\psi}. \tag{51}$$

Consequently, equation (40) becomes

$$\frac{W_t}{W_{t-1}} = \frac{W_t^*}{W_{t-1}^*} \cdot \\ \frac{(1+g)exp(\mu_t)}{(1+g^*)exp(\mu_t^*)} exp\left\{ (\frac{\gamma(1-\epsilon)(1-\zeta)}{\gamma(1-\epsilon)(1-\zeta)+\zeta(1+\gamma)})[(\Delta a_z(t) - \Delta a_z^*(t)) + (v_t - v_{t-1}) - (v_t^* - v_{t-1}^*)] \right\}, \tag{52}$$

where $\Delta a_z(t) = a_z(t) - a_z(t-1)$ and $\Delta a_z^*(t) = a_z^*(t) - a_z^*(t-1)$. Without loss of generality, we can normalize W_{t-1} to be 1, and set $v_{t-1} = v_{t-1}^* = 0$. Therefore, as long as we can find the expression of W_t^* in terms of state variables and shocks, we can find the home and foreign wage growth as functions of state variables and shocks.

Thus, under assumptions (a) and (b), we next solve for W_t^*.

Lemma 4. *Under assumptions (a) and (b), the wage growth rates in the home and foreign countries are explicit functions of shocks and state variables.*

Proof: Substituting equation (50) into the foreign version of equation (17), we have

$$\begin{aligned} W_t^* &= \frac{\kappa M_t^*}{\chi \psi^*}(L_t^*)^\gamma \\ &= \frac{\kappa M_t^*}{\chi \psi^*} \kappa^{\frac{-\gamma}{1+\gamma}} (C_t^*)^{\frac{\gamma(1-\zeta)}{1+\gamma}} \\ &= \frac{\kappa^{\frac{1}{1+\gamma}} M_{t-1}^*(1+g^*)exp(\mu_t^*)}{\chi \psi^*} (C_t^*)^{\frac{\gamma(1-\zeta)}{1+\gamma}}, \end{aligned} \tag{53}$$

where the second equality follows from Lemma 1. Note that the foreign version of equation (20) and Lemma 2 imply

$$\begin{aligned} C_t^* &= C_{t-1}^* (\frac{P_{t-1}^* \lambda_{t-1}^*}{P_t^* \lambda_t^*})^{\frac{1}{\zeta}} \\ &= C_{t-1}^* (\frac{P_{t-1}^*(1+g^*)exp(\mu_t^*)}{P_t^*})^{\frac{1}{\zeta}}. \end{aligned}$$

Substituting the last line into equation (53) and using the definition for P_t^*, we obtain

$$W_t^* = \frac{\kappa^{\frac{1}{1+\gamma}} M_{t-1}^*(1+g^*)exp(\mu_t^*)}{\chi\psi^*}[C_{t-1}^*(\frac{P_{t-1}^*(1+g^*)exp(\mu_t^*)}{P_t^*})^{\frac{1}{\zeta}}]^{\frac{\gamma(1-\zeta)}{1+\gamma}}$$
$$= \frac{\kappa^{\frac{1}{1+\gamma}} M_{t-1}^*[(1+g^*)exp(\mu_t^*)]^{\frac{\zeta+\gamma}{\zeta(1+\gamma)}}(C_{t-1}^*)^{\frac{\gamma(1-\zeta)}{1+\gamma}}(P_{t-1}^*)^{\frac{\gamma(1-\zeta)}{\zeta(1+\gamma)}}}{\chi\psi^*}(P_t^*)^{\frac{\gamma(\zeta-1)}{\zeta(1+\gamma)}}$$
$$= \frac{\kappa^{\frac{1}{1+\gamma}} M_{t-1}^*[(1+g^*)exp(\mu_t^*)]^{\frac{\zeta+\gamma}{\zeta(1+\gamma)}}(C_{t-1}^*)^{\frac{\gamma(1-\zeta)}{1+\gamma}}(P_{t-1}^*)^{\frac{\gamma(1-\zeta)}{\zeta(1+\gamma)}}}{\chi\psi^*}\cdot$$
$$[\epsilon^{-\epsilon}(1-\epsilon)^{\epsilon-1}]^{\frac{\gamma(\zeta-1)}{\zeta(1+\gamma)}}[\int_0^1(P_{it}^*)^{1-\eta}di]^{\frac{1}{1-\eta}\epsilon\frac{\gamma(\zeta-1)}{\zeta(1+\gamma)}}(P_{zt}^*)^{(1-\epsilon)\frac{\gamma(\zeta-1)}{\zeta(1+\gamma)}}$$
$$= \frac{\kappa^{\frac{1}{1+\gamma}} M_{t-1}^*[(1+g^*)exp(\mu_t^*)]^{\frac{\zeta+\gamma}{\zeta(1+\gamma)}}(C_{t-1}^*)^{\frac{\gamma(1-\zeta)}{1+\gamma}}(P_{t-1}^*)^{\frac{\gamma(1-\zeta)}{\zeta(1+\gamma)}}[\epsilon^{-\epsilon}(1-\epsilon)^{\epsilon-1}]^{\frac{\gamma(\zeta-1)}{\zeta(1+\gamma)}}}{\chi\psi^*}\cdot$$
$$[\int_0^k(\frac{W_t}{e_tA_iexp(a(t)+u_t)})^{1-\eta}di+\int_k^1(\frac{W_t^*}{A_i^*exp(a^*(t)+u_t^*)})^{1-\eta}di]^{\frac{\epsilon\gamma(\zeta-1)}{\zeta(1+\gamma)(1-\eta)}}[\frac{W_t^*}{A_z^*exp(a_z^*(t)+v_t^*)}]^{\frac{\gamma(1-\epsilon)(\zeta-1)}{\zeta(1+\gamma)}}.$$

Using equation (40) to eliminate W_t from the right hand side yields

$$W_t^* = \frac{\kappa^{\frac{1}{1+\gamma}} M_{t-1}^*[(1+g^*)exp(\mu_t^*)]^{\frac{\zeta+\gamma}{\zeta(1+\gamma)}}(C_{t-1}^*)^{\frac{\gamma(1-\zeta)}{1+\gamma}}(P_{t-1}^*)^{\frac{\gamma(1-\zeta)}{\zeta(1+\gamma)}}[\epsilon^{-\epsilon}(1-\epsilon)^{\epsilon-1}]^{\frac{\gamma(\zeta-1)}{\zeta(1+\gamma)}}}{\chi\psi^*}\cdot$$
$$\Big\{\int_0^k(\frac{W_{t-1}}{W_{t-1}^*e_{t-1}})^{1-\eta}exp[\frac{\gamma(1-\epsilon)(1-\zeta)(1-\eta)}{\gamma(1-\epsilon)+\zeta(1+\gamma\epsilon)}(\Delta a_z(t)-\Delta a_z^*(t)+v_t-v_t^*)][\frac{W_t^*}{A_iexp(a(t)+u_t)}]^{1-\eta}di+$$
$$\int_k^1[\frac{W_t^*}{A_i^*exp(a^*(t)+u_t^*)}]^{1-\eta}di\Big\}^{\frac{\epsilon\gamma(\zeta-1)}{\zeta(1+\gamma)(1-\eta)}}[\frac{W_t^*}{A_z^*exp(a_z^*(t)+v_t^*)}]^{\frac{\gamma(1-\epsilon)(\zeta-1)}{\zeta(1+\gamma)}} \Rightarrow$$
$$W_t^* = \frac{\kappa^{\frac{1}{1+\gamma}} M_{t-1}^*[(1+g^*)exp(\mu_t^*)]^{\frac{\zeta+\gamma}{\zeta(1+\gamma)}}(C_{t-1}^*)^{\frac{\gamma(1-\zeta)}{1+\gamma}}(P_{t-1}^*)^{\frac{\gamma(1-\zeta)}{\zeta(1+\gamma)}}[\epsilon^{-\epsilon}(1-\epsilon)^{\epsilon-1}]^{\frac{\gamma(\zeta-1)}{\zeta(1+\gamma)}}}{\chi\psi^*}\cdot$$
$$\Big\{\int_0^k(\frac{W_{t-1}}{e_{t-1}})^{1-\eta}exp[\frac{\gamma(1-\epsilon)(1-\zeta)(1-\eta)}{\gamma(1-\epsilon)+\zeta(1+\gamma\epsilon)}(\Delta a_z(t)-\Delta a_z^*(t)+v_t-v_t^*)][\frac{1}{A_iexp(a(t)+u_t)}]^{1-\eta}di+$$
$$\int_k^1[\frac{1}{A_i^*exp(a^*(t)+u_t^*)}]^{1-\eta}di\Big\}^{\frac{\epsilon\gamma(\zeta-1)}{\zeta(1+\gamma)(1-\eta)}}[\frac{1}{A_z^*exp(a_z^*(t)+v_t^*)}]^{\frac{\gamma(1-\epsilon)(\zeta-1)}{\zeta(1+\gamma)}}(W_t^*)^{\frac{\gamma(\zeta-1)}{\zeta(1+\gamma)}} \Rightarrow$$
$$(W_t^*)^{\frac{\zeta+\gamma}{\zeta(1+\gamma)}} = \frac{\kappa^{\frac{1}{1+\gamma}} M_{t-1}^*[(1+g^*)exp(\mu_t^*)]^{\frac{\zeta+\gamma}{\zeta(1+\gamma)}}(C_{t-1}^*)^{\frac{\gamma(1-\zeta)}{1+\gamma}}(P_{t-1}^*)^{\frac{\gamma(1-\zeta)}{\zeta(1+\gamma)}}[\epsilon^{-\epsilon}(1-\epsilon)^{\epsilon-1}]^{\frac{\gamma(\zeta-1)}{\zeta(1+\gamma)}}}{\chi\psi^*}\cdot$$
$$\Big\{\int_0^k(\frac{W_{t-1}}{e_{t-1}})^{1-\eta}exp[\frac{\gamma(1-\epsilon)(1-\zeta)(1-\eta)}{\gamma(1-\epsilon)+\zeta(1+\gamma\epsilon)}(\Delta a_z(t)-\Delta a_z^*(t)+v_t-v_t^*)][\frac{1}{A_iexp(a(t)+u_t)}]^{1-\eta}di+$$
$$\int_k^1[\frac{1}{A_i^*exp(a^*(t)+u_t^*)}]^{1-\eta}di\Big\}^{\frac{\epsilon\gamma(\zeta-1)}{\zeta(1+\gamma)(1-\eta)}}[\frac{1}{A_z^*exp(a_z^*(t)+v_t^*)}]^{\frac{\gamma(1-\epsilon)(\zeta-1)}{\zeta(1+\gamma)}}.$$

Rearranging the last equation and normalizing W_{t-1}^* to be one yield

$$
\begin{aligned}
\frac{W_t^*}{W_{t-1}^*} &= (1+g^*)exp(\mu_t^*)\cdot \\
&\Big\{(\frac{W_{t-1}}{e_{t-1}})^{1-\eta} exp[\frac{\gamma(1-\epsilon)(1-\zeta)(1-\eta)}{\gamma(1-\epsilon)+\zeta(1+\epsilon\gamma)}(\Delta a_z(t) - \Delta a_z^*(t) + v_t - v_t^*)] exp[(\eta-1)(a(t)+u_t)] \int_0^k A_i^{\eta-1} di + \\
&\quad exp[(\eta-1)(a^*(t)+u_t^*)] \int_k^1 (A_i^*)^{\eta-1} di \Big\}^{\frac{\epsilon\gamma(\zeta-1)}{(1-\eta)(\zeta+\gamma)}} \cdot \\
&[A_z^* exp(a_z^*(t)+v_t^*)]^{\frac{\gamma(1-\epsilon)(1-\zeta)}{\zeta+\gamma}} \cdot \\
&\frac{\kappa^{\frac{\zeta}{\zeta+\gamma}} (M_{t-1}^*)^{\frac{\zeta(1+\gamma)}{\zeta+\gamma}} (C_{t-1}^*)^{\frac{\zeta\gamma(1-\zeta)}{\zeta+\gamma}} (P_{t-1}^*)^{\frac{\gamma(1-\zeta)}{\zeta+\gamma}} [\epsilon^{-\epsilon}(1-\epsilon)^{\epsilon-1}]^{\frac{\gamma(\zeta-1)}{\zeta+\gamma}}}{(\chi\psi^*)^{\frac{\zeta(1+\gamma)}{\zeta+\gamma}}}.
\end{aligned} \tag{54}
$$

Similarly, we can obtain the home wage growth as (see Appendix for derivation)

$$
\begin{aligned}
\frac{W_t}{W_{t-1}} &= \frac{M_t}{M_{t-1}} \cdot \\
&\Big\{ exp[(\eta-1)(a(t)+u_t)] \int_0^k A_i^{\eta-1} di + \\
&\quad (\frac{W_{t-1}}{e_{t-1}})^{-(1-\eta)} exp[-\frac{\gamma(1-\epsilon)(1-\zeta)(1-\eta)}{\gamma(1-\epsilon)+\zeta(1+\epsilon\gamma)}(\Delta a_z(t) - \Delta a_z^*(t) + v_t - v_t^*)] exp[(\eta-1)(a^*(t)+u_t^*)] \int_k^1 (A_i^*)^{\eta-1} di \Big\}^{\frac{\epsilon\gamma(\zeta-1)}{(1-\eta)(\zeta+\gamma)}} \cdot \\
&[A_z exp(a_z(t)+v_t)]^{\frac{\gamma(1-\epsilon)(1-\zeta)}{\zeta+\gamma}} \cdot \\
&\frac{\kappa^{\frac{\zeta}{\zeta+\gamma}} M_{t-1}^{\frac{\zeta(\gamma+1)}{\zeta+\gamma}} C_{t-1}^{\frac{\zeta\gamma(\zeta-1)}{\zeta+\gamma}} P_{t-1}^{\frac{\gamma(1-\zeta)}{\zeta+\gamma}} [\epsilon^{-\epsilon}(1-\epsilon)^{\epsilon-1}]^{\frac{\gamma(\zeta-1)}{\zeta+\gamma}}}{(\chi\psi)^{\frac{\zeta(1+\gamma)}{\zeta+\gamma}} W_{t-1}}.
\end{aligned} \tag{55}
$$

In equations (54) and (55), the cutoff variety k is determined by

$$\frac{W_t}{A_k exp(a(t)+u_t)} = \frac{W_t^* e_t}{A_k^* exp(a^*(t)+u_t^*)}.$$

If the exchange rate is flexible, by equation (51), the change in exchange rate is determined by

$$\frac{e_t}{e_{t-1}} = \frac{(1+g)exp(\mu_t)}{(1+g^*)exp(\mu_t^*)}. \tag{56}$$

If the exchange rate is fixed, $e_t/e_{t-1} = 1$. ■

In each of equations (54) and (55), the first line is the effect of monetary factors on wage growth, which we will refer to as the monetary effects. The second and third lines are the effects of the productivity shocks through the prices of traded goods. The fourth line is the effect of the productivity shocks to nontraded sectors, through the price of nontraded goods. We will refer to the second, the third and the fourth lines as the productivity effects. The fifth line contains constants that depend on parameters and past values of endogenous variables. Assume that $\zeta > 1$ and $\eta > 1$, i.e. the relative risk aversion coefficient and the elasticity of substitution between traded goods are greater than 1. The assumptions imply

$$\begin{aligned}\frac{\gamma(1-\epsilon)(1-\zeta)(1-\eta)}{\gamma(1-\epsilon)+\zeta(1+\epsilon\gamma)} &> 0, \\ \frac{\epsilon(\zeta-1)}{(1-\eta)(\zeta+\gamma)} &< 0, \\ \frac{(1-\epsilon)(1-\zeta)}{\zeta+\gamma} &< 0.\end{aligned}$$

Here, we make a few more observations on the relationship between wage and productivities. First, W_t/W_{t-1} is decreasing in u_t and u_t^*, the productivity shocks associated with home and foreign traded goods. The intuition is that when productivities improve, output prices will tend to drop. Consequently, a lower nominal wage is required to solicit sufficient labor supply. This is why increases in u_t and u_t^* lead to lower wages.

Second, W_t/W_{t-1} is increasing in $v_t - v_t^*$, the relative productivity shock associated with the home nontraded goods. Note that the relative productivity shock $v_t - v_t^*$ raises the price of the imported varieties in the home country (see the term associated with the second integral in equation (55)). This term shows up in the prices of traded goods because to eliminate W_t^*, we use equation (40), which can be traced back to equations (37) and (28). When productivity in home nontraded good sector improves faster than the foreign, home price of nontraded good and hence home wage will drop faster. This makes the imported goods more expensive because the foreign wage is higher relative to the home wage. This effect can be viewed as the effects of productivities in nontraded goods on the relative prices of traded goods.

Third, the overall effect of v_t on W_t/W_{t-1} is ambiguous. From the third line of equation (55), we can see that the direct effect of v_t to W_t/W_{t-1} is negative because it lowers the price of the nontraded good in home. Therefore, combined with the previous observation, the overall effect of v_t is ambiguous.

By symmetry, similar observations hold for the foreign country.

We now derive Proposition 2 regarding wage comovements under different exchange rate regimes.

Proposition 2. *Assume that both monetary shocks are independent from the productivity shocks. Wage comovements between the countries are more positive or less negative under the fixed exchange rate regime (assumptions (a), (b) and (c2)), compared to the flexible exchange rate regime (assumptions (a), (b) and (c1)).*

Proof: We maintain the normalization $W_{t-1} = 1$. Substituting equation (54) back into (40), we obtain an alternative expression for home wage growth

$$\begin{aligned}\frac{W_t}{W_{t-1}} = {} & \frac{e_t}{e_{t-1}} exp[\frac{\gamma(1-\epsilon)(1-\zeta)}{\gamma(1-\epsilon)+\zeta+\zeta\epsilon\gamma}(\Delta a_z(t) - \Delta a_z^*(t) - v_t - v_t^*)] \cdot \\ & (1+g^*)exp(\mu_t^*) \cdot \\ & \Big\{ (\frac{W_{t-1}}{e_{t-1}})^{1-\eta} exp[\frac{\gamma(1-\epsilon)(1-\zeta)(1-\eta)}{\gamma(1-\epsilon)+\zeta(1+\epsilon\gamma)}(\Delta a_z(t) - \Delta a_z^*(t) + v_t - v_t^*)] exp[(\eta-1)(a(t)+u_t)] \int_0^k A_i^{\eta-1} di + \\ & \quad exp[(\eta-1)(a^*(t)+u_t^*)] \int_k^1 (A_i^*)^{\eta-1} di \Big\}^{\frac{\epsilon\gamma(\zeta-1)}{(1-\eta)(\zeta+\gamma)}} \cdot \\ & [A_z^* exp(a_z^*(t) + v_t^*)]^{\frac{\gamma(1-\epsilon)(1-\zeta)}{\zeta+\gamma}} \cdot \\ & \frac{\kappa^{\frac{\zeta}{\zeta+\gamma}} (M_{t-1}^*)^{\frac{\zeta(1+\gamma)}{\zeta+\gamma}} (C_{t-1}^*)^{\frac{\zeta\gamma(1-\zeta)}{\zeta+\gamma}} (P_{t-1}^*)^{\frac{\gamma(1-\zeta)}{\zeta+\gamma}} [\epsilon^{-\epsilon}(1-\epsilon)^{\epsilon-1}]^{\frac{\gamma(\zeta-1)}{\zeta+\gamma}}}{(\chi\psi^*)^{\frac{\zeta(1+\gamma)}{\zeta+\gamma}}}. \end{aligned} \tag{57}$$

To reduce notation clusters, define

$$
\begin{aligned}
exp[d_t(v_t, v_t*)] &= exp[\frac{\gamma(1-\epsilon)(1-\zeta)}{\gamma(1-\epsilon)+\zeta+\zeta\epsilon\gamma}(\Delta a_z(t) - \Delta a_z^*(t) + v_t - v_t^*)], \\
exp[f_t(u_t, u_t^*, v_t, v_t^*)] &= \left\{(\frac{W_{t-1}}{e_{t-1}})^{1-\eta} exp[\frac{\gamma(1-\epsilon)(1-\zeta)(1-\eta)}{\gamma(1-\epsilon)+\zeta(1+\epsilon\gamma)}(\Delta a_z(t) - \Delta a_z^*(t) + v_t - v_t^*)] exp[(\eta-1)(a(t)+u_t)] \int_0^k A_i^{\eta-1} di + \right. \\
& \left. exp[(\eta-1)(a^*(t)+u_t^*)] \int_k^1 (A_i^*)^{\eta-1} di \right\}^{\frac{\epsilon\gamma(\zeta-1)}{(1-\eta)(\zeta+\gamma)}} \cdot \\
& [A_z^* exp(a_z^*(t) + v_t^*)]^{\frac{\gamma(1-\epsilon)(1-\zeta)}{\zeta+\gamma}} \cdot \\
& \frac{\kappa^{\frac{\zeta}{\zeta+\gamma}} (M_{t-1}^*)^{\frac{\zeta(1+\gamma)}{\zeta+\gamma}} (C_{t-1}^*)^{\frac{\zeta\gamma(1-\zeta)}{\zeta+\gamma}} (P_{t-1}^*)^{\frac{\gamma(1-\zeta)}{\zeta+\gamma}} [\epsilon^{-\epsilon}(1-\epsilon)^{\epsilon-1}]^{\frac{\gamma(\zeta-1)}{\zeta+\gamma}}}{(\chi\psi^*)^{\frac{\zeta(1+\gamma)}{\zeta+\gamma}}},
\end{aligned}
$$

such that the random variables d_t and f_t are functions of the underlying productivity shocks. With the definitions, under the fixed exchange rate regime, equation (57) can be rewritten as

$$ln(\frac{W_t}{W_{t-1}}) = ln(1+g^*) + \mu_t^* + d_t + f_t.$$

Note that under the flexible exchange rate regime

$$\frac{e_t}{e_{t-1}} = \frac{(1+g)exp(\mu_t)}{(1+g^*)exp(\mu_t^*)}.$$

Hence, under the flexible exchange rate regime, equation (57) becomes

$$ln(\frac{W_t}{W_{t-1}}) = ln(1+g) + \mu_t + d_t + f_t.$$

Similarly, equation (54) is rewritten as

$$ln(\frac{W_t^*}{W_{t-1}^*}) = ln(1+g^*) + \mu_t^* + f_t.$$

Therefore, under the fixed exchange rate regime, the correlation coefficient between home and foreign wage growth is

$$
\begin{aligned}
corr^{FX}[ln(\frac{W_t}{W_{t-1}}), ln(\frac{W_t^*}{W_{t-1}^*})] &= \frac{cov(\mu_t^* + d_t + f_t, \mu_t^* + f_t)}{[var(\mu_t^* + d_t + f_t)]^{\frac{1}{2}}[var(\mu_t^* + f_t)]^{\frac{1}{2}}} \\
&= \frac{var(\mu_t^*) + cov(d_t + f_t, f_t)}{[var(\mu_t^*) + var(d_t + f_t)]^{\frac{1}{2}}[var(\mu_t^*) + var(f_t)]^{\frac{1}{2}}},
\end{aligned}
$$

where the second equality follows from the assumption that both monetary shocks are independent from the productivity shocks. Under the flexible regime, the correlation coefficient between home and foreign wage growth is

$$
\begin{aligned}
corr^{FL}[ln(\frac{W_t}{W_{t-1}}), ln(\frac{W_t^*}{W_{t-1}^*})] &= \frac{cov(\mu_t + d_t + f_t, \mu_t^* + f_t)}{[var(\mu_t + d_t + f_t)]^{\frac{1}{2}}[var(\mu_t^* + f_t)]^{\frac{1}{2}}} \\
&= \frac{cov(\mu_t, \mu_t^*) + cov(d_t + f_t, f_t)}{[var(\mu_t) + var(d_t + f_t)]^{\frac{1}{2}}[var(\mu_t^*) + var(f_t)]^{\frac{1}{2}}} \\
&= \frac{cov(\mu_t, \mu_t^*) + cov(d_t + f_t, f_t)}{[var(\mu_t^*) + var(d_t + f_t)]^{\frac{1}{2}}[var(\mu_t^*) + var(f_t)]^{\frac{1}{2}}},
\end{aligned}
$$

where the last equality follows from assumption (c1), which states that the monetary shocks have the same marginal distributions. Because $var(\mu_t - \mu_t^*) \geq 0$ implies

$$var(\mu_t) + var(\mu_t^*) \geq 2 \cdot cov(\mu_t, \mu_t^*),$$

or

$$var(\mu_t^*) \geq cov(\mu_t, \mu_t^*),$$

it follows that

$$corr^{FX}[ln(\frac{W_t}{W_{t-1}}), ln(\frac{W_t^*}{W_{t-1}^*})] - corr^{FL}[ln(\frac{W_t}{W_{t-1}}), ln(\frac{W_t^*}{W_{t-1}^*})]$$
$$= \frac{var(\mu_t^*) - cov(\mu_t, \mu_t^*)}{[var(\mu_t^*) + var(d_t + f_t)]^{\frac{1}{2}} [var(\mu_t^*) + var(f_t)]^{\frac{1}{2}}} \geq 0,$$

where the strict equality holds only when μ_t and μ_t^* are perfectly correlated. ■

Intuitively, when the exchange rate regime is fixed, the comovements between home and foreign wages are caused by both the identical monetary effects $(ln(1 + g^*)exp(\mu_t^*))$ and the correlation in the productivity effects. 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 productivity effects.

Finally, we obtain the following corollary for the case of $\zeta = 1$.

Corollary 1. *Under assumption (a), and if $\zeta = 1$ (i.e. the utility from consumption has the log form), then*

$$\frac{W_t^*}{W_{t-1}^*} = (1 + g^*)exp(\mu_t^*),$$
$$\frac{W_t}{W_{t-1}} = \frac{e_t}{e_{t-1}}(1 + g^*)exp(\mu_t^*),$$

and the wage comovements are perfectly positive under a fixed exchange rate regime. Under the flexible regime, the wage comovements are positive only if μ_t and μ_t^* are positively correlated.

Proof: Setting $\zeta = 1$ in equation (53) for period t and $t-1$, we get

$$W_t^* = \frac{\kappa^{\frac{1}{1+\gamma}} M_{t-1}^*(1+g^*)exp(\mu_t^*)}{\chi\psi^*},$$
$$W_{t-1}^* = \frac{\kappa^{\frac{1}{1+\gamma}} M_{t-2}^*(1+g^*)exp(\mu_{t-1}^*)}{\chi\psi^*}.$$

Thus we obtain

$$\frac{W_t^*}{W_{t-1}^*} = \frac{exp(\mu_t^*)M_{t-1}^*}{exp(\mu_{t-1}^*)M_{t-2}^*}.$$

Using equation (48), the last equation becomes

$$\frac{W_t^*}{W_{t-1}^*} = \frac{exp(\mu_t^*)exp(\mu_{t-1}^*)(1+g^*)M_{t-2}^*}{exp(\mu_{t-1}^*)M_{t-2}^*} \Rightarrow$$
$$\frac{W_t^*}{W_{t-1}^*} = exp(\mu_t^*)(1+g^*). \tag{58}$$

Setting $\zeta = 1$ in equation (40) gives

$$\frac{W_t}{W_{t-1}} = \frac{W_t^*}{W_{t-1}^*}\frac{e_t}{e_{t-1}}.$$

Substituting equation (58) into the above, we obtain

$$\frac{W_t}{W_{t-1}} = exp(\mu_t^*)(1+g^*)\frac{e_t}{e_{t-1}}. \tag{59}$$

If the exchange rate is fixed, from equations (58) and (59), we obtain

$$\frac{W_t^*}{W_{t-1}^*} = \frac{W_t}{W_{t-1}} = exp(\mu_t^*)(1+g^*),$$

which indicates perfect comovements.

If the exchange rate is flexible, by substituting equation (56) into (59), we have

$$\frac{W_t}{W_{t-1}} = exp(\mu_t)(1+g). \tag{60}$$

Equations (58) and (60) indicate that the wage comovements are positive only if μ_t^* and μ_t are positively correlated. ■

In this case, while the monetary shocks affect changes in wages, the productivities do not. The productivities affect only quantities of consumption and trade. Thus, as argued by Duarte et al. (2007), the relationship between nominal exchange rates and macroeconomic variables may depend on the nature of shocks.

In this section, we have constructed a dynamic Ricardian model with money and nominal exchange rate. The model implies that if the exchange rate with a trade partner is fixed, then the wage in the home country will have stronger positive comovements with that of the trade partner. On the other hand, if the exchange rate with the trade partner is floating, then the wage in the home country does not necessarily comove with that of the trade partner due to the flexibility in the exchange rate. The key mechanism is the following. In each country, a change in nominal wage is linked directly to the change in money supply. When the exchange rate is fixed, the growth rates in money supplies must be equal in the two countries, implying a common growth rate in nominal wages in the two countries. Meanwhile, when the exchange rate is flexible, money growth rates and wage growth rates in the two countries are not correlated in general. [5]

[5] Note that the key predictions developed here also hold in the framework of the standard static Ricardian model, and in the standard H-O model. For the argument in a static Ricardian model, see the earlier version of this paper Kurokawa et al. (2011). In the standard H-O model, by incorporating a nominal exchange rate and using the factor price equalization theorem, we obtain $W = eW^*$ and $R = eR^*$, where R and R^* are the home and foreign rentals, respectively. Thus it is obvious that under the fixed exchange rate regime, the home and foreign wages W and W^* would comove strongly and positively.

3 Empirical Evidence

To test our theory, we will 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 the exchange rate regime. To be specific, Proposition 2 states a key testable prediction that the wage comovements are stronger under a fixed exchange rate regime than under a floating regime.

3.1 Regression specification

In this subsection, we derive from our theory the regression specification that guides our empirical work. Taking the log of equation (40) and applying assumption (b), we have the following equation

$$\begin{aligned}
&ln(\frac{W_t}{W_{t-1}}) = ln(\frac{W_t^*}{W_{t-1}^*}) + ln(\frac{e_t}{e_{t-1}}) + \frac{\gamma(1-\epsilon)(1-\zeta)}{\gamma(1-\epsilon)+\zeta(1+\gamma\epsilon)} \cdot ln(\frac{A_{zt}A_{zt-1}^*}{A_{zt-1}A_{zt}^*}) \Rightarrow \\
&ln(\frac{W_t}{W_{t-1}}) = ln(\frac{W_t^*}{W_{t-1}^*}) + ln(\frac{e_t}{e_{t-1}}) + \frac{\gamma(1-\epsilon)(1-\zeta)}{\gamma(1-\epsilon)+\zeta(1+\gamma\epsilon)} \cdot (\Delta a_z(t) - \Delta a_z^*(t)) + \frac{\gamma(1-\epsilon)(1-\zeta)}{\gamma(1-\epsilon)+\zeta(1+\gamma\epsilon)} \cdot (v_t - v_t^*).
\end{aligned} \tag{61}$$

Because of the observed productivity slow-down since the 1970s, we posit that the productivities have quadratic trends. To be specific, we assume that

$$a_z(t) = \sigma_0 + \sigma_1 t + \sigma_2 t^2,$$

$$a_z^*(t) = \sigma_0^* + \sigma_1^* t + \sigma_2^* t^2,$$

where $\sigma_0, \sigma_1, \sigma_2, \sigma_0^*, \sigma_1^*$, and σ_2^* are constants. Under these assumptions of quadratic trends, equation (61) becomes

$$\begin{aligned}
ln(\frac{W_t}{W_{t-1}}) = {} & ln(\frac{W_t^*}{W_{t-1}^*}) + ln(\frac{e_t}{e_{t-1}}) + \frac{\gamma(1-\epsilon)(1-\zeta)}{\gamma(1-\epsilon)+\zeta(1+\gamma\epsilon)} \cdot (\sigma_1 - \sigma_1^* - \sigma_2 + \sigma_2^*) + \frac{\gamma(1-\epsilon)(1-\zeta)}{\gamma(1-\epsilon)+\zeta(1+\gamma\epsilon)} \cdot 2(\sigma_2 - \sigma_2^*) \cdot t \\
& + \frac{\gamma(1-\epsilon)(1-\zeta)}{\gamma(1-\epsilon)+\zeta(1+\gamma\epsilon)} \cdot (v_t - v_t^*).
\end{aligned} \tag{62}$$

The terms $(\sigma_1 - \sigma_1^* - \sigma_2 + \sigma_2^*)$ and $2(\sigma_2 - \sigma_2^*) \cdot t$ capture the difference between two countries' quadratic trends in productivities of nontraded goods. In a panel regression framework, $(\sigma_1 - \sigma_1^* - \sigma_2 + \sigma_2^*)$ is constant for a country and its main economic partner. Therefore, the last equation implies the presence of fixed effects in regressions. The term $(\sigma_2 - \sigma_2^*) \cdot t$ indicates the existence of a linear trend in the difference of home and foreign wage growth rates, and this trend is specific to a country and its main economic partner. The term $(v_t - v_t^*)$ is a zero-mean random variable that exhibits first order autocorrelation. This term is absorbed into the error term of regressions.

Equation (62), which is derived from Proposition 1 and the assumption of quadratic productivity trends, suggests the following linear relationship between home wage, foreign wage, exchange rate, and productivity trends:

$$ln(\frac{W_{it}}{W_{it-1}}) = \alpha_0 + \alpha_1 \cdot ln(\frac{W_{it}^*}{W_{it-1}^*}) + \alpha_2 \cdot ln(\frac{e_{it}}{e_{it-1}}) + \alpha_{3,i} \cdot d_i \cdot t + \omega_i + \epsilon_{it}.$$

Moreover, because Proposition 2 states that the wage comovements will be stronger under the fixed exchange rate regime, we include the interaction term between fixed exchange rate regime and foreign wage in the following estimation equation

$$\begin{aligned} ln(\frac{W_{it}}{W_{it-1}}) = \beta_0 + \beta_1 \cdot ln(\frac{W_{it}^*}{W_{it-1}^*}) + \beta_2 \cdot ln(\frac{W_{it}^*}{W_{it-1}^*}) \cdot peg_{it} \\ + \beta_3 \cdot ln(\frac{e_{it}}{e_{it-1}}) + \beta_{4,i} \cdot d_i \cdot t + \omega_i + \epsilon_{it}, \end{aligned} \tag{63}$$

where W_{it} is the wage index of country i, W_{it}^* is the wage index for the main economic partner of country i, and e_{it} is the nominal exchange rate between country i and its main economic partner. The indicator variable peg_{it} is equal to 1 if a country i pegs its exchange rate to its base country, and it is equal to 0 otherwise. The variable d_i is an indicator variable for country i, and hence $d_i \cdot t$ corresponds to the term $(\sigma_2 - \sigma_2^*) \cdot t$ in equation

(62), the linear time trend in wage differences specific to a country and its main economic partner. The variable ω_i is the fixed effect for country i that corresponds to the term $(\sigma_1 - \sigma_1^* - \sigma_2 + \sigma_2^*)$ in equation (62). The quantity ϵ_{it} is the error term. β_0, β_1, β_2, β_3, and β_4 are coefficients to be estimated.

Our intention is to use the regression analysis to estimate partial correlation between home and foreign wage growth rates under different exchange rate regimes. We do not intend to identify causality between the wages because they are equilibrium objects. In particular, the coefficient β_1 measures the wage comovements between a country and its partner when the exchange rate is flexible. Meanwhile, β_2 measures the additional wage comovements experienced by countries with a fixed exchange rate regime relative to those with a floating regime. The sum $\beta_1 + \beta_2$ is thus the aggregate wage comovements for countries with a fixed regime. Proposition 2 is substantiated if $\beta_2 > 0$.

Because our specification incorporates quadratic 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 wage data from the OECD Library (www.oecd-ilibrary.org), which provides detailed wage information of OECD countries starting from 1973. Wage is measured by the index for nominal hourly earnings in manufacturing sectors. Our choice of wage measurement, identical to that in Levchenko and Zhang (2011), is consistent with the theory that requires a country-specific measure for wage.

The classification of the exchange rate regime follows Klein and Shambaugh (2006), who determine whether a country pegs its currency to the base country, based on the volatility of the exchange rate. In Klein and Shambaugh (2006), country i's base country is the country to which country i pegs its exchange rate or the country with which country

i has the most significant trade relationship. For each country in the sample, we use base countries identified by Klein and Shambaugh (2006) as its main economic partner.[6]

In our model, we implicitly assume that the exchange rate peg is credible. However, in practice non-currency-union pegs often lack credibility compared to the currency union (Obstfeld and Rogoff, 1995b).[7] Historically, countries had been known to break their pegs and devalue when the prices of their products were not competitive internationally. If producers expect such devaluations, then there are smaller incentives to align 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 peg indicator with the foreign wage growth. In such regressions, the reference group include 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.

The countries included in our sample are Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Hungary, Iceland, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, Spain, Sweden, Turkey, and the UK. The US is not in the sample because the US does not have a dominant trade-partner to be used as the base country. Because we are looking at OECD countries, the currency union is the EMU. Our sample covers data from the first quarter of 1973 to the fourth quarter of 2012. The details about the base country, episodes of exchange rate pegs, and data range for each country are documented in Table 1. We report summary

[6]The description of their data can be found at www.dartmouth.edu/~jshambau/

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

statistics in Table 2.

3.3 Main regression results

We run regressions with growth rates of wages calculated over different time intervals. This is because our model assumes perfect wage flexibility that is more likely to be true in the long run, and regressions over different time intervals will reveal whether the prediction of the model is more accurate in longer time horizon. The top rows in Table 3 through Table 6 indicate the frequency at which we calculate the growth rates of the wage in country i and its base country. We choose to use the wage growth over a quarter, a year, two years, and four years.

Table 3 reports the wage comovements under different exchange rate regimes. In this analysis, a country's exchange rate regime is considered to be fixed if it is a member of the EMU or engages in a non-currency union peg with its main economic partner ($peg_{it} = 1$). The coefficient on the interaction term ($peg_{it} \times \Delta ln(W^*_{it})$) is generally insignificant, suggesting that Proposition 2 is not supported if both non-currency union pegs and the EMU are considered as fixed exchange rate regimes.

In order to present directly the overall wage comovements of countries with peg regimes, in the row below the estimated constants in Table 3, we report the coefficient on the wage growth in the base country ($\Delta ln(W^*_{it})$) when the exchange rate is pegged. This coefficient is just the sum of β_1 and β_2 in Equation (63), or the sum of the coefficients from the first two rows. From this row of coefficients, we see that in general, there is no positive wage comovements for countries with peg regimes. Overall, Table 3 seems unsupportive to our hypothesis. 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 a new dummy variable EMU_{it}. It is equal to 1 if country i and its base country are both in the EMU in period t, and 0 otherwise. We then repeat the analysis of Table 3 by replacing peg_{it} with this new dummy variable, and report the results in Table 4. The interaction term between the EMU indicator and wage growth in the base country ($EMU_{it} \times \Delta ln(W_{it}^*)$) is always positive and significant, suggesting that being in the EMU is associated with stronger wage comovements. The magnitude of the coefficient is also economically meaningful. For instance, at the quarterly frequency, the coefficient on the interaction between the EMU indicator and wage growth in the base country is 0.67. This result implies that if the wage in country i's base country increases by 1%, being in the EMU with the base country predicts an additional increase of 0.67% in country i's wage relative to the cases where a country floats its exchange rate against the base country or engage in a non-currency-union peg. At the other three frequencies over which we calculate the wage changes, the coefficients on the interaction term are all significant and larger, with coefficient estimates greater than 1. This is consistent with Proposition 2.

Meanwhile, as indicated by the coefficient of wage growth in the base country ($\Delta ln(W_{it}^*)$) in Tables 3 and 4, if the exchange rate is flexible, wages in general do not comove positively between a country and its base country. The only exception is the regressions at the quarterly frequency. To conserve space, we do not report the coefficients on the terms $d_i \cdot t$ that are country pair-specific, but they are almost always significant at 5% level. This suggests that there indeed exist differences in the trend of wage growth rates among the countries in the sample.

Although in this paper we focus on the effect of trade and exchange rate regimes on nominal wage comovements, we recognize that capital flow can also lead to comovements of nominal wages. For instance, as mentioned in the introduction, Budd et al. (2002) suggest that through internal risk sharing, nominal wages can comove within multinational firms that are necessarily established through foreign direct investment (FDI). Therefore, we add two variables related to capital flow to the regressions in Table 4. The first is the FDI stock to GDP ratio, and the second is the interaction between the FDI stock to GDP ratio with the variable EMU_{it}. The idea is to check whether the presence of FDI affects nominal wage growth, particularly for countries in the EMU. In these regressions, the FDI-related variables are generally not significant. Meanwhile, the coefficient on the interaction term between base country wage growth and the EMU ($EMU_{it} \times \Delta ln(W_{it}^{*})$) remains positive and significant, except that it becomes insignificant at the annual frequency. To preserve space, we do not report the results in the paper, but will make them available upon request.[8]

3.4 EMU countries vs. non-EMU countries

In Table 5, we repeat the estimations in Table 4 but restrict the sample to countries currently in the EMU. More specifically, the countries included are Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, the Netherlands, Portugal, and Spain. The time range remains 1973 to 2012. The purpose of these estimations is to check whether wage comovements became more positive during the EMU era than the pre-EMU era. Compared to Table 4, the coefficients on the interaction between the EMU indicator and the base country wage growth ($EMU_{it} \times \Delta ln(W_{it}^{*})$) in Table 5 remain positive and significant. Hence, for the same 11 countries, the positive wage comovements with their base countries after joining the EMU appear to be stronger than before joining the EMU. This finding also supports Proposition 2.

We also run regressions with the countries not in the EMU to examine whether non-currency union pegs affect wage comovements. The results are presented in Table

[8]The source of FDI data is the IFS dataset. Because the IFS only provide net flows of FDI, we impute the FDI stock as the sum of past net flows after subtracting a 10% linear depreciation per year.

6, and they suggest that non-currency-union pegs have no strengthening effect on wage comovements in non-EMU countries. Overall, the regression results in Table 5 and Table 6 indicate that the EMU, but not the non-currency-union pegs, is associated with stronger and positive wage comovements.

4 Conclusion

We have constructed a dynamic Ricardian model of trade with money and nominal exchange rate and obtained the prediction that two countries' nominal wages must exhibit strong and positive comovements if they fix the bilateral exchange rate. We have used the data from 24 OECD countries between 1973 and 2012 to test this prediction. We have found that if a country and its main trade partner were in the EMU, their wages experienced stronger comovements. Restricting our attention to the EMU members, we have also found a significant increase in wage comovements after they joined the EMU in 1999 compared to the period before 1999. In comparison, when the sample is restricted to the non-EMU countries, we have found no evidence that non-currency union pegs affected the wage comovements.

Our results enhance the understanding of wages in international economics in a number of ways. First, by explicitly introducing money and exchange rate into a Ricardian trade model, our model suggests that whether a country's nominal wage comoves with its main trade partner depends on the type of exchange rate regime. Second, compared to previous works that emphasize risk-sharing or emigration as the cause of nominal wage comovements, we highlight that the combination of extensive trade and fixed exchange rate regime can also drive nominal wage comovements. Third, a fixed exchange rate regime can provide, to some extent, an anchor for nominal wages, in addition to nominal prices.

In addition, our model is related to the literature on the relationship between the relative price of non-traded goods and the bilateral real exchange rate. In two recent papers on the subject, Betts and Kehoe (2006) and Betts and Kehoe (2008), one of the key findings is that for pairs of countries which trade intensively or maintain a stable bilateral real exchange rate, the relative price of non-traded goods has a stronger relationship with their bilateral real exchange rate. In the dynamic Ricardian model in our paper, a similar result holds. It can be shown that when the exchange rate is fixed, the real exchange rate is determined by the relative price of non-traded goods.[9]

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 wage comovements suggests that although relative to the US, the EMU originally was less likely to meet the criteria for optimum currency area (Feenstra and Taylor, 2008, p.879), it may have enhanced the economic integration of its members via wage comovements.

Finally, it is worth noting that Schmitt-Grohé and Uribe (2013) have recently pointed out that there are 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 found in this paper may not contain enough downward movements.

Appendix: derivation of home wage in Lemma 4

Substituting equation (49) into equation (17), we have

$$\begin{aligned} W_t &= \frac{\kappa M_t}{\chi \psi} L_t^{\gamma} \\ &= \frac{\kappa^{\frac{1}{1+\gamma}} M_t}{\chi \psi} C_t^{\frac{\gamma(1-\zeta)}{1+\gamma}}, \end{aligned} \tag{64}$$

[9]The price index for aggregate consumption good in the home country is $P_t = [\epsilon^{-\epsilon}(1-\epsilon)^{\epsilon-1}](\int_0^1 P_{it}^{1-\eta})^{\frac{1}{1-\eta}\epsilon}(P_{zt})^{1-\epsilon}$. Hence the real exchange rate is $re_t = e_t \frac{P_t^*}{P_t} = e_t^{1-\epsilon}(\frac{P_{zt}^*}{P_{zt}})^{1-\epsilon}$.

where the second equality follows from Lemma 1. Note that equation (20) and Lemma 2 imply

$$C_t = C_{t-1}(\frac{P_{t-1}\lambda_{t-1}}{P_t\lambda_t})^{\frac{1}{\zeta}}$$
$$= C_{t-1}(\frac{P_{t-1}M_t}{P_tM_{t-1}})^{\frac{1}{\zeta}}.$$

Substituting the last line into equation (64), we obtain

$$W_t = \frac{\kappa^{\frac{1}{1+\gamma}}M_t}{\chi\psi}C_{t-1}^{\frac{\gamma(1-\zeta)}{1+\gamma}}(\frac{P_{t-1}M_t}{P_tM_{t-1}})^{\frac{\gamma(1-\zeta)}{\zeta(1+\gamma)}}$$
$$= \frac{\kappa^{\frac{1}{1+\gamma}}M_t^{\frac{\zeta+\gamma}{\zeta(1+\gamma)}}C_{t-1}^{\frac{\gamma(1-\zeta)}{1+\gamma}}(\frac{P_{t-1}}{M_{t-1}})^{\frac{\gamma(1-\zeta)}{\zeta(1+\gamma)}}}{\chi\psi}P_t^{\frac{\gamma(\zeta-1)}{\zeta(1+\gamma)}}.$$

Substituting equation (1), the expression for P_t, and the expressions for P_{it} and P_{zt}, we have

$$W_t = \frac{\kappa^{\frac{1}{1+\gamma}}M_t^{\frac{\zeta+\gamma}{\zeta(1+\gamma)}}C_{t-1}^{\frac{\gamma(1-\zeta)}{1+\gamma}}(\frac{P_{t-1}}{M_{t-1}})^{\frac{\gamma(1-\zeta)}{\zeta(1+\gamma)}}[\epsilon^{-\epsilon}(1-\epsilon)^{\epsilon-1}]^{\frac{\gamma(\zeta-1)}{\zeta(1+\gamma)}}}{\chi\psi}\cdot$$
$$[\int_0^k(\frac{W_t}{A_iexp(a(t)+u_t)})^{1-\eta}di + \int_k^1(\frac{W_t^*e_t}{A_i^*exp(a^*(t)+u_t^*)})^{1-\eta}di]^{\frac{\epsilon\gamma(\zeta-1)}{(1-\eta)\zeta(1+\gamma)}}(\frac{W_t}{A_zexp(a_z(t)+v_t)})^{\frac{\gamma(1-\epsilon)(\zeta-1)}{\zeta(1+\gamma)}}.$$

Rewriting equation (40) as

$$W_t^* = \frac{W_t}{W_{t-1}}\frac{e_{t-1}}{e_t}exp[\frac{\gamma(1-\epsilon)(\zeta-1)}{\gamma(1-\epsilon)+\zeta(1+\epsilon\gamma)}(\Delta a_z(t) - \Delta a_z^*(t) + v_t - v_t^*)],$$

and using it to eliminate W_t^* from the previous expression, we obtain

$$W_t = \frac{\kappa^{\frac{1}{1+\gamma}} M_t^{\frac{\zeta+\gamma}{\zeta(1+\gamma)}} C_{t-1}^{\frac{\gamma(1-\zeta)}{1+\gamma}} (\frac{P_{t-1}}{M_{t-1}})^{\frac{\gamma(1-\zeta)}{\zeta(1+\gamma)}} [\epsilon^{-\epsilon}(1-\epsilon)^{\epsilon-1}]^{\frac{\gamma(\zeta-1)}{\zeta(1+\gamma)}}}{\chi\psi} \cdot$$

$$\left\{\int_0^k (\frac{W_t}{A_i exp(a(t)+u_t)})^{1-\eta} di + \int_k^1 [W_t \frac{e_{t-1}}{W_{t-1}} exp[\frac{\gamma(1-\epsilon)(\zeta-1)}{\gamma(1-\epsilon)+\zeta(1+\epsilon\gamma)}(\Delta a_z(t) - \Delta a_z^*(t) + v_t - v_t^*)] \frac{1}{A_i^* exp(a^*(t)+u_t^*)}]^{1-\eta} di\right\}^{\frac{\epsilon\gamma(\zeta-1)}{(1-\eta)\zeta(1+\gamma)}} \cdot$$

$$(\frac{W_t}{A_z exp(a_z(t)+v_t)})^{\frac{\gamma(1-\epsilon)(\zeta-1)}{\zeta(1+\gamma)}} \Rightarrow$$

$$W_t^{\frac{\zeta+\gamma}{\zeta(1+\gamma)}} = \frac{\kappa^{\frac{1}{1+\gamma}} M_t^{\frac{\zeta+\gamma}{\zeta(1+\gamma)}} C_{t-1}^{\frac{\gamma(1-\zeta)}{1+\gamma}} (\frac{P_{t-1}}{M_{t-1}})^{\frac{\gamma(1-\zeta)}{\zeta(1+\gamma)}} [\epsilon^{-\epsilon}(1-\epsilon)^{\epsilon-1}]^{\frac{\gamma(\zeta-1)}{\zeta(1+\gamma)}}}{\chi\psi} \cdot$$

$$\Big\{exp[(\eta-1)(a(t)+u_t)] \int_0^k A_i^{\eta-1} di +$$

$$(\frac{e_{t-1}}{W_{t-1}})^{1-\eta} exp[\frac{\gamma(1-\epsilon)(\zeta-1)(1-\eta)}{\gamma(1-\epsilon)+\zeta(1+\epsilon\gamma)}(\Delta a_z(t) - \Delta a_z^*(t) + v_t - v_t^*)] exp[(\eta-1)(a^*(t)+u_t^*)] \int_k^1 (A_i^*)^{\eta-1} di\Big\}^{\frac{\epsilon\gamma(\zeta-1)}{(1-\eta)\zeta(1+\gamma)}} \cdot$$

$$[A_z exp(a_z(t)+v_t)]^{\frac{\gamma(1-\epsilon)(1-\zeta)}{\zeta(1+\gamma)}}.$$

Rearrangement yields

$$\frac{W_t}{W_{t-1}} = \frac{M_t}{M_{t-1}} \cdot$$

$$\Big\{exp[(\eta-1)(a(t)+u_t)] \int_0^k A_i^{\eta-1} di +$$

$$(\frac{W_{t-1}}{e_{t-1}})^{-(1-\eta)} exp[-\frac{\gamma(1-\epsilon)(1-\zeta)(1-\eta)}{\gamma(1-\epsilon)+\zeta(1+\epsilon\gamma)}(\Delta a_z(t) - \Delta a_z^*(t) + v_t - v_t^*)] exp[(\eta-1)(a^*(t)+u_t^*)] \int_k^1 (A_i^*)^{\eta-1} di\Big\}^{\frac{\epsilon\gamma(\zeta-1)}{(1-\eta)(\zeta+\gamma)}} \cdot$$

$$[A_z exp(a_z(t)+v_t)]^{\frac{\gamma(1-\epsilon)(1-\zeta)}{\zeta+\gamma}} \cdot$$

$$\frac{\kappa^{\frac{\zeta}{\zeta+\gamma}} M_{t-1}^{\frac{\zeta(1+\gamma)}{\zeta+\gamma}} C_{t-1}^{\frac{\zeta\gamma(1-\zeta)}{\zeta+\gamma}} P_{t-1}^{\frac{\gamma(1-\zeta)}{\zeta+\gamma}} [\epsilon^{-\epsilon}(1-\epsilon)^{\epsilon-1}]^{\frac{\gamma(\zeta-1)}{\zeta+\gamma}}}{(\chi\psi)^{\frac{\zeta(1+\gamma)}{\zeta+\gamma}} W_{t-1}}.$$

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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 1999			
Austria	Germany	1975-1998	1973q1-2012q3
Belgium	Germany	1975-1980, 1984-1992, 1994-1998	1973q1-2012q3
Finland	Germany	1975, 1979, 1987, 1990, 1997-1998	1973q1-2012q4
France	Germany	1979-1980, 1984-1985, 1987-1994, 1996-1998	1973q1-2012q4
Germany	US		1973q1-2012q3
Ireland	Germany	1979-1980, 1984-1985, 1987-1992, 1998	1979q1-2012q4
Italy	Germany	1980, 1984, 1986, 1988, 1990-1991, 1997-1998	1973q1-2012q4
Luxembourg	Belgium	1973-1998	1980q1-2012q4
Netherlands	Germany	1975-1976, 1978-1998	1973q1-2012q4
Portugal	Germany		2000q1-2012q4
Spain	Germany	1996-1998	1981q1-2012q4
Country in ERM II			
Denmark	Germany	1975-1976, 1978, 1980, 1983-1992, 1994-2012	1973q1-2012q4
Other countries			
Australia	US		1984q1-2012q4
Canada	US	1973-1974, 1983, 1986, 1990-1991, 1996	1973q1-2012q4
Japan	US		1973q1-2012q4
Korea	US	1992-1994	1992q1-2012q4
Mexico	US		1980q1-2012q4
Hungary	Germany	1999	1995q1-2010q3
New Zealand	Australia	1978-1980, 1988, 1992-1993	1989q1-2012q4
Norway	Germany	1975-1996, 1984, 1990-1991, 1994	1973q1-2012q4
Poland	Germany		1995q1-2012q4
Sweden	Germany	1974-1975, 2003-2004	1973q1-2012q4
Turkey	US		1988q1-2012q4
UK	Germany		1973q1-2012q4

Notes: (1) Prior to 1979, the UK is 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-quarter observations
quarterly change in nominal wage (%)					
flexible	2.19	3.20	-6.53	30.13	2049
non-currency-union pegs	1.16	1.56	-6.55	26.11	781
European Monetary Union	0.70	1.11	-6.55	5.53	601
quarterly change in nominal exchange rate (%)					
flexible	1.70	7.68	-59.36	118.75	2456
non-currency-union pegs	0.15	1.44	-6.74	23.4	930
European Monetary Union	0	0	0	0	402

Notes: We classify country-quarter observations into three categories according to exchange rate regimes: flexible regime, non-currency-union pegs, and membership in the EMU. All correlation coefficients reported are significant at 1% level.

Table 3: Effects of exchange rate pegs on wage comovements

	quarterly	annual	2-year	4-year
Variables	(1)	(2)	(3)	(4)
$\Delta ln(W^*_{it})$	0.25	-.005	-.11	-.31
	(0.1)**	(0.28)	(0.33)	(0.39)
$peg_{it} \times \Delta ln(W^*_{it})$	-.12	-.27	-.46	-.39
	(0.11)	(0.17)	(0.28)*	(0.24)
$\Delta ln(e_{it})$	0.05	0.09	0.14	0.18
	(0.04)	(0.07)	(0.11)	(0.13)
$d_i \times t$	included	included	included	included
fixed effects	included	included	included	included
Const.	0.04	1.72	0.14	0.29
	(0.001)***	(0.56)***	(0.03)***	(0.07)***
Overall wage comovements	0.13	-.27	-.57	-.70
when the exchange rate is pegged	(0.12)	(0.37)	(0.51)	(0.55)
Obs.	3236	1076	568	298
R^2	0.43	0.21	0.25	0.32

Notes: (1) The dependent variable is the wage growth rate as measured by the log change in wages. (2) The variable $\Delta\ ln(W^*_{it})$ is the wage growth rate of the base country, and peg_{it} is a dummy variable indicating whether a country pegs its exchange rate to its base country via a currency union or other arrangements. The variable e_{it} is the bilateral nominal exchange rate between country i and its base country. (3) The top row indicates the time interval at which the wage growth rates are calculated. (4) In the row below the constants, each number is the sum of the corresponding coefficients from the first two rows. This number measures the overall wage comovements of countries with peg regimes. (5) The numbers in the parentheses are clustered standard errors that are robust to heteroskedasticity across countries and serial correlation in error terms. (6) *, **, and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively.

Table 4: Effects of the EMU on wage comovements

Variables	quarterly (1)	annual (2)	2-year (3)	4-year (4)
$\Delta ln(W_{it}^*)$	0.15	-.17	-.31	-.45
	(0.1)*	(0.32)	(0.37)	(0.41)
$EMU_{it} \times \Delta ln(W_{it}^*)$	0.68	1.02	1.45	1.31
	(0.21)***	(0.39)***	(0.48)***	(0.67)*
$\Delta ln(e_{it})$	0.05	0.09	0.15	0.18
	(0.04)	(0.07)	(0.11)	(0.14)
$d_i \times t$	included	included	included	included
fixed effects	included	included	included	included
Const.	0.04	2.31	0.15	0.31
	(0.001)***	(0.7)***	(0.03)***	(0.07)***
Overall wage comovements when the country is in EMU	0.83	0.84	1.15	0.87
	(0.19)***	(0.35)**	(0.48)**	(0.63)
Obs.	3212	1070	564	295
R^2	0.43	0.2	0.24	0.31

Notes: (1) The dependent variable is the wage growth rate as measured by the log change in wages. (2) The variable $\Delta\ ln(W_{it}^*)$ is the wage growth rate of the base country, and EMU_{it} is a dummy variable indicating membership of the European Monetary Union. The variable e_{it} is the bilateral nominal exchange rate between country i and its base country. (3) The top row indicates the time interval at which the wage growth rates are calculated. (4) In the row below the constants, each number is the sum of the corresponding coefficients from the first two rows. This number measures the overall wage comovements of EMU member countries during the euro era. (5) The numbers in the parentheses are clustered standard errors that are robust to heteroskedasticity across countries and serial correlation in error terms. (6) *, **, and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively.

Table 5: Restricting the sample to EMU countries

	quarterly	annual	2-year	4-year
Variables	(1)	(2)	(3)	(4)
$\Delta ln(W^*_{it})$	0.2	0.24	0.17	0.04
	(0.07)***	(0.24)	(0.27)	(0.29)
$EMU_{it} \times \Delta ln(W^*_{it})$	0.65	0.7	1.16	0.89
	(0.21)***	(0.27)**	(0.4)***	(0.5)*
$\Delta ln(e_{it})$	-.009	0.005	0.02	0.07
	(0.02)	(0.03)	(0.04)	(0.09)
$d_i \times t$	included	included	included	included
fixed effects	included	included	included	included
Const.	0.03	3.48	0.14	0.29
	(0.002)***	(0.58)***	(0.03)***	(0.06)***
Overall wage comovements when the country is in EMU	0.84	0.94	1.33	0.93
	(0.19)***	(0.39)**	(0.58)**	(0.69)
Obs.	1549	446	236	123
R^2	0.35	0.52	0.62	0.69

Notes: (1) The dependent variable is the wage growth rate as measured by the log change in wages. (2) The variable $\Delta\ ln(W^*_{it})$ is the wage growth rate of the base country, and EMU_{it} is a dummy variable indicating membership of the European Monetary Union. The variable e_{it} is the bilateral nominal exchange rate between country i and its base country. (3) The top row indicates the time interval at which the wage growth rates are calculated. (4) In the row below the constants, each number is the sum of the corresponding coefficients from the first two rows. This number measures the overall wage comovements of EMU member countries during the euro era. (5) The numbers in the parentheses are clustered standard errors that are robust to heteroskedasticity across countries and serial correlation in error terms. (6) *, **, and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively.

Table 6: Restricting the sample to non-EMU countries

	quarterly	annual	2-year	4-year
Variables	(1)	(2)	(3)	(4)
$\Delta ln(W^*_{it})$	0.15	-.31	-.44	-.81
	(0.15)	(0.32)	(0.39)	(0.63)
$non\text{-}CU\ peg_{it} \times \Delta ln(W^*_{it})$	-.01	-.11	-.41	-.82
	(0.2)	(0.18)	(0.43)	(0.57)
$\Delta ln(e_{it})$	0.05	0.1	0.16	0.17
	(0.04)	(0.08)	(0.12)	(0.13)
$d_i \times t$	included	included	included	included
fixed effects	included	included	included	included
Const.	0.06	0.53	0.13	0.33
	(0.002)***	(0.62)	(0.04)***	(0.12)***
Overall wage comovements when the exchange rate is pegged	0.14	-.42	-.85	-1.63
	(0.29)	(0.43)	(0.70)	(1.14)
Obs.	1830	731	374	187
R^2	0.46	0.18	0.21	0.27

Notes: (1) The dependent variable is the wage growth rate as measured by the log change in wages. (2) The variable $\Delta\ ln(W^*_{it})$ is the wage growth rate of the base country, and $non\text{-}CU\ peg_{it}$ is a dummy variable indicating whether a country engages in a peg other than being a member of a currency union. The variable e_{it} is the bilateral nominal exchange rate between country i and its base country. (3) The top row indicates the time interval at which the wage growth rates are calculated. (4) In the row below the constants, each number is the sum of the corresponding coefficients from the first two rows. This number measures the overall wage comovements of countries with non-currency-union pegs. (5) The numbers in the parentheses are clustered standard errors that are robust to heteroskedasticity across countries and serial correlation in error terms. (6) *, **, and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively.