The Effect of Exchange-Rate Fluctuations on Employment in a Segmented Labor Market*

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Abstract

How does the exchange-rate fluctuation affect the employment of regular and non-regular workers in a segmented labor market? We investigate the effect of the exchange-rate fluctuation on the employment adjustment of regular and non-regular workers using heterogeneous dependence on international trade across firms for identification. The analysis of Japanese firm-level panel data reveals that appreciation of the Yen decreases the employment of exporting firms. The adjustment elasticity of non-regular employment is about 5 times greater than that of regular employment. Regular employment reacts more to the permanent exchange rate shocks extracted by the Beverage and Nelson decomposition, whereas non-regular employment reacts less. The estimation results suggest a significant difference of adjustment costs between regular and non-regular employment in the Japanese segmented labor market.

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1 Introduction

In the aftermath of the US financial crisis, which peaked in summer 2008 with the collapse of Lehman Brothers, the Japanese Yen appreciated by more than 25%, and it coincided with a surge of the unemployment rate from 4% to 5.5%, as shown in Figure 1. During this turbulent time, the job loss of non-regular workers, whose employment is less protected than that of regular workers, attracted much attention from media and policy makers. As exemplified by this episode, policy makers frequently discuss whether swings in the exchange rate cause swings in employment, particularly that of non-regular workers.[1] The causal effect of the exchange rate on employment requires that monetary and fiscal authorities formulate exchange-rate policies that take their impacts on employment into consideration. Moreover, the exchange-rate policy has a distributional consequence if the cost of the exchange-rate fluctuation falls especially on non-regular workers in segmented labor markets, which are pervasive in some continental European countries and South Korea, as well as Japan.

The causal effect of the exchange-rate fluctuation on employment outcomes has long attracted researchers and policy makers' attention because of its significant implications for monetary and fiscal policies. Reflecting this attention, numerous empirical studies examine the effect of the exchange-rate fluctuation on employment adjustment. Studies based on industry-level data include Brunello (1990), Dekle (1998), and Tomiura (2003) for Japan, Gourinchas (1999a) and Campa and Goldberg (2001) for the US, and Gourinchas (1999b) for France. Recent studies based on firm-level gross job flow data include Klein et al. (2003) for the US and Moser et al. (2010) for Germany. These studies exploit heterogeneous dependence on international trade across industries for identification. Klein et al. (2003) report that the exchange-rate fluctuation significantly affects net job flow through job destruction in the US, while Moser et al. (2010) find a similar effect on

[1] Koichi Hamada, a Special Adviser to the Cabinet of the Prime Minister Shinzo Abe, later blamed the Bank of Japan for not expanding its balance sheet sufficiently to counter the balance-sheet expansion of the Federal Reserve Bank of the US and European Central Bank that allegedly caused a sudden Yen appreciation and subsequent job loss in exporting industries. He went as far as to claim that the Bank of Japan caused the bankruptcy of Elpida Memory, Inc., which heavily depended on exports and went bankrupt in February 2012 (Press conference at Foreign Correspondents' Club on January 18, 2013).

net job flow but through job creation in Germany; for firms in exporting industries, appreciation of own currency destructs jobs in the US, whereas it suppresses job creation in Germany. The difference in results probably reflects the strictness of employment protection legislation across the two countries. The negative labor demand shock created by the exchange-rate fluctuation is absorbed by firing existing workers in the US, whereas it is absorbed by suppressing recruitment in Germany. The contrasting results from the US and Germany highlight the significant role of labor-market institutions in the process of labor reallocation during the exchange-rate adjustment.

Heterogeneity of employment adjustment costs arises within a country where the labor market is segmented because regular and non-regular workers have different degrees of employment protection. The differential employment protection between regular and non-regular employment contracts tends to make employers rely on non-regular workers to absorb exogenous shocks and thus results in segmented labor markets within a country (OECD 2014). A strand of literature examines the differential adjustments of regular and non-regular workers in response to exogenous shocks (Hunt 2000, Houseman 2001, Holmlund and Storrie 2002, Varejo and Portugal 2007, Hijzen et al. 2015). Much less is known, however, about the differential elasticities of employment adjustment between regular and non-regular workers based on a credibly exogenous source of labor demand shock that is heterogeneous across firms. Our aims in this study are twofold. First, we attempt to fill the gap of policy makers' interest and the literature by estimating the causal effect of exchange-rate fluctuations on the employment adjustment of regular and non-regular workers. Second, we examine the differential adjustment costs between regular and non-regular workers using exchange-rate fluctuations combined with heterogeneous dependence on international trade across firms as the source of exogenous variation for labor demand.

Nucci and Pozzolo (2010) is the closest study to ours that examines the impact of the exchange-rate fluctuation on employment adjustment exploiting firms' heterogeneity in the exposure to international trade. Recent literature reveals that only a fraction of firms within an industry have access to international trade (Melitz and Redding 2014), but studies that exploit the industry-level variation in trade exposure do not use firm-level heterogeneity in international trade exposure to estimate the causal relationship. Nucci and Pozzolo (2010) use unique Italian firm-level panel data that record costs of foreign purchases and revenues from foreign sales, along with the usual accounting information. They shed light on the impacts of the exchange-rate fluctuation on employment and working hours across Italian firms, exploiting heterogeneous dependence on export across firms for identification, and find that the appreciation in Italian Lira increases both employment and hours of importing firms, while it decreases those of exporting firms. They do not pay attention, however, to the differential impacts on regular and non-regular workers. Hosono et al. (2013) examine the effect of Yen appreciation on firms' performance comparing exporting and non-exporting firms using the same data set as in our study; they find that exporting firms suffer from the sudden appreciation of the Yen and cut the employment of term-contracted workers after the 2008 financial crisis. They, however, do not systematically examine the impact of the exchange rate on regular and non-regular employment. Hanagaki and Hori (2015) examine the effect of exchange rate fluctuation on firms' performance, such as sales and return on assets (ROA), exploiting the heterogeneous dependence on international trade, drawing on the same data set as in our study, and find that Yen depreciation boosts net exporters' (those firms whose export amount exceeds import amount) performance, on average. They do not pay attention, however, to its effect on employment.

The current study draws from firm-level panel data collected in the Basic Survey of Japanese Business Structure and Activities conducted by the Ministry of Economy, Trade and Industry that covers all enterprises with 50 or more employees and whose paid-up capital or investment fund is over 30 million Yen, operating in wide range of industries. This survey records information on each company's level of dependence on foreign trade and the numbers of employees of different contract forms. We exploit the heterogeneity in the dependence on international trade to identify the impact of exchange fluctuation on employment adjustment; for example, the impact of Yen appreciation on employment is examined by comparing the changes of employment in exporting firms – the treatment group – and non-exporting firms – the control group – in a virtually difference-in-differences framework. We furthermore consider two types of exchange-rate shocks: permanent and temporary. As Nucci and Pozzolo (2001) pointed out in the context of physical investment, firms are unlikely to modify their employment levels after temporary fluctuations of exchange rates in the presence of adjustment costs. For this reason, we extract the trend component of exchange-rate variations from the observed exchange-rate fluctuation using the Beveridge-Nelson decomposition. We then examine how employment responds to permanent shocks, using the trend component of the exchange-rate fluctuation as the instrumental variable (IV); the standard IV estimator recovers the employment response to the permanent exchange-rate shock based on the local average treatment effects (LATE) interpretation of the IV estimator.

The empirical analysis reveals that the appreciation of Yen increases the sales and the employment of exporting firms; to take a firm that exports 10% of its total sales as an example, a 10% appreciation of Japanese Yen measured in the real effective exchange rate decreases sales by around 9%, regular employment by about 1.7%, and non-regular employment by about 8%. The elasticity of non-regular workers is about 5 times larger than that of regular workers, and this implies a significant difference in the adjustment costs between regular and non-regular employments. Regular employment reacts more to the permanent change of the exchange rate than to the transitory change, whereas non-regular employment reacts more to the transitory component than to the permanent component. These findings imply that firms use non-regular workers as an adjustment margin for a transitory exchange-rate fluctuation. Contrary to the findings for exporting firms, the appreciation of Japanese Yen does not increase the regular or non-regular employment of importing firms, perhaps because the effect of price changes of foreign intermediate inputs, such as energy, propagates to the firms that do not directly import intermediate inputs.

2 Theoretical Model

This section introduces a dynamic model of a firm that maximizes the discounted sum of future profits, using regular and non-regular workers as inputs. The firm incurs an adjustment cost for changing the number of regular workers, while it does not incur such a cost for non-regular workers. Nucci and Pozzolo (2001, 2014) introduce q theory of physical capital investment to consider the effect of the exchange rate on it. The key idea here is that physical capital investment, I_t, requires an convex adjustment cost $C(I_t)$ with properties $C', C'' > 0$. We apply this theory to the employment adjustment of regular workers, because it also incurs an adjustment cost $C(I_t)$, given the cost of recruiting new workers and firing existing workers. We define the short-run as the period during which regular workers cannot be adjusted according to the standard convention. We modify the model by Nucci and Pozzolo (2001, 2014) by replacing the stock of capital K with the stock of regular workers R. The first difference of R, ΔR, represents a net flow into the pool of regular workers, which requires adjustment cost $C(\Delta R_t)$ that $C', C'' > 0$.

The following Bellman equation for the state variable, R_t, characterizes the firm's dynamic profit maximization:

$$V_t(R_{t-1}) = \max_{\Delta R_t} \Big(\pi(R_t, e_t) - C(\Delta R_t) + \beta E_t \left[V_{t+1}(R_t) \right] \Big) \tag{1}$$

Note that there is no adjustment cost for non-regular workers, and thus it does not appear in the Bellman equation that includes only the state variables. The parameter β is a constant discount factor. The regular-worker stock is governed by the accumulation equation for R_t; $R_t = (1 - \delta)R_{t-1} + \Delta R_t$, where δ is the natural rate of job separation.

Applying the envelope theorem renders the Euler equation that characterizes the optimal path of regular worker adjustment:

$$\frac{\partial V_t}{\partial R_{t-1}} = \frac{\partial \pi(R_t, e_t)}{\partial R_t} \frac{\partial R_t}{\partial R_{t-1}} + \beta E_t \left[\frac{\partial V_{t+1}}{\partial R_t} \frac{\partial R_t}{\partial R_{t-1}} \right] = \frac{\partial \pi(R_t, e_t)}{\partial R_t}(1-\delta) + \beta E_t \left[\frac{\partial V_{t+1}}{\partial R_t}(1-\delta) \right] \tag{2}$$

We denote $\partial V_t / \partial R_{t-1}$ as q_t, representing the shadow value of regular workers. q_t, Equation 2 can be summarized as follows:

$$q_t = \frac{\partial \pi(R_t, e_t)}{\partial R_t}(1-\delta) + \beta(1-\delta)E_t \left[q_{t+1} \right] \tag{3}$$

Repeating the substitution of q_{t+j}, Equation 3 can be summarized as follows:

$$
\begin{aligned}
q_t &= \frac{\partial \pi(R_t, e_t)}{\partial R_t}(1-\delta) + \beta E_t \left[\left(\frac{\partial \pi(R_{t+1}, e_{t+1})}{\partial R_{t+1}}(1-\delta) + \beta E_{t+1}\left[q_{t+2}(1-\delta)\right] \right)(1-\delta) \right] \\
&= E_t \sum_{j=0}^{\infty} \beta(1-\delta)^{j+1} \left(\frac{\partial \pi(R_{t+j}, e_{t+j})}{\partial R_{t+j}} \right)
\end{aligned}
\tag{4}
$$

Equation 4 means that q_t is equivalent to the discounted present value of the marginal profit of regular-workers.

The first-order condition with respect of ΔR_t can be calculated from Equation 1 as follows:

$$
\frac{\partial C(\Delta R_t)}{\partial \Delta R_t} = \frac{1}{1-\delta} q_t \tag{5}
$$

Given the increasing and convex shape of $C(\Delta R_t)$, ΔR_t is an increasing function of q_t. Substituting Equation 4, ΔR_t can be expressed as an increasing function g $(g' > 0)$ of the expected present value of marginal profits, as follows:

$$
\Delta R_t = g(q_t) = g\left[E_t \sum_{j=0}^{\infty} \beta(1-\delta)^{j+1} \left(\frac{\partial \pi(R_{t+j}, e_{t+j})}{\partial R_{t+j}} \right) \right] \tag{6}
$$

Note that the increasing property of $g(\cdot)$ comes from the adjustment costs of regular workers. To explore the impact of exchange rates on regular workers, we need to know the sequence of the marginal profitability of regular workers. To derive this, we will solve the static profit-maximization problem.

We assume that the firm has market power in both domestic and foreign markets and faces downward sloping inverse demand functions. The firm maximizes profits in each period subject to a certain production technology that consists of a quasi-fixed factor, regular workers, and non-regular workers (N_t), as in Campa and Goldberg (2001) and Nucci and Pozzolo (2001). The firm does not have market power in the labor market, and the wages of regular and non-regular workers are given at w^R and w^N, respectively.

$$\pi(R_t, e_t) = \max_{Q_t, Q_t^*, N_t} Q_t p(Q_t) + e_t Q_t^* p^*(Q_t^*) - w_t^R R_t - w_t^N N_t \tag{7}$$
$$s.t.\ Q_t + Q_t^* = F(R_t, N_t)$$

where e_t is the exchange rate of Yen for a foreign currency unit and an increase in e_t means a Yen's depreciation.

The Lagrangian function for this optimization problem can be written as follows:

$$\mathcal{L} = Q_t p(Q_t) + e_t Q_t^* p^*(Q_t^*) - w_t^R R_t - w_t^N N_t + \lambda_t \Big(F(R_t, N_t) - Q_t - Q_t^* \Big) \tag{8}$$

Then, the first-order conditions can be solved in the following way:

$$\frac{\partial \mathcal{L}}{\partial Q_t} = p'(Q_t) Q_t + p_t - \lambda_t = 0 \tag{9}$$
$$\frac{\partial \mathcal{L}}{\partial Q_t^*} = p'^*(Q_t^*) Q_t^* + e_t p_t^* - \lambda_t = 0 \tag{10}$$
$$\frac{\partial \mathcal{L}}{\partial N_t} = -w_t^N + \lambda_t F_{Nt} = 0 \tag{11}$$

From Equations 9 and 10, we obtain the marginal value of output, which is:

$$\lambda_t = p_t \Big(1 + \frac{1}{\eta_t} \Big) = e_t p_t^* \Big(1 + \frac{1}{\eta_t^*} \Big) \tag{12}$$

where $\eta_t = (p_t/Q_t)(\partial Q_t/\partial p_t)$ and $\eta_t^* = (p_t^*/Q_t^*)(\partial Q_t^*/\partial p_t^*)$. The stronger domestic and foreign market powers are, the smaller these demand elasticities become. From Equation A.19, we obtain the optimality condition for non-regular workers:

$$p_t \Big(1 + \frac{1}{\eta_t} \Big) F_{Nt} = e_t p_t^* \Big(1 + \frac{1}{\eta_t^*} \Big) F_{Nt} = w_t^N \tag{13}$$

This equation implies that N_t increases in response to an increase in the domestic price p_t, the foreign price p_t^*, and the depreciation of Japanese Yen (increase in e_t).

Using the envelope theorem and Equations 7 and 12, if we consider the long-run optimal path of regular workers, we have:

$$\frac{\partial \pi_t}{\partial R_t} = -w_t^R + \lambda_t F_{R_t} = -w_t^R + p_t\left(1 + \frac{1}{\eta_t}\right) F_{R_t} \tag{14}$$

We assume constant returns to scale for the production function. By Euler's theorem:

$$F(R_t, N_t) = F_{R_t} R_t + F_{N_t} N_t \tag{15}$$

Let $1/\mu_t$ and $1/\mu_t^*$ be the mark-up ratios in the domestic and foreign product markets, respectively. Then, we have:

$$\lambda_t = \frac{p_t}{\mu_t} = \frac{e_t p_t^*}{\mu_t^*} \tag{16}$$

Assuming that the exchange rate is the only source of uncertainty and varies permanently, the expected value of the marginal profit of capital stock in the future is equal to the marginal profit at time t, the Equation 6 is reconfigured as below:

$$\Delta R_t = g\left(\frac{1-\delta}{1-\beta(1-\delta)} \frac{\partial \pi(R_t, e_t)}{\partial R_t}\right) \tag{17}$$

Partially differentiating ΔR_t and ΔN_t by the exchange rate e_t, the effects of a shift in the exchange rate on the inflow of regular and non-regular workers are expressed as follows:[2]

$$\frac{\partial \Delta R}{\partial e} = g_q(\cdot) \frac{1-\delta}{1-\beta(1-\delta)} \frac{\partial^2 \pi}{\partial R \partial e} \tag{18}$$

$$\frac{\partial \Delta N}{\partial e} = \frac{\overline{\eta_{W^N e}} w^N}{pe\left(1 + \frac{1}{\eta}\right) F_{NN}} - \frac{\eta_{pe} F_N}{e F_{NN}} \tag{19}$$

[2]From now on, for simplicity, we shall omit the explicit time notation.

The expansion of the last term in Equation 18 yields the next expression:[3]

$$\frac{\partial^2 \pi}{\partial R \partial e} = g_q(\cdot)\frac{1-\delta}{1-\beta(1-\delta)}\frac{pQ+p^*Q^*}{Re}\left[\frac{1}{\mu}(1-\chi)\big(\eta_{pe}(1+\eta)-\varepsilon_{\eta e}\big)\right.$$
$$\left. +\frac{1}{\mu^*}\chi\big(\eta_{p^*e}(1+\eta^*)+1-\varepsilon_{\eta^* e}\big)-\left(\overline{\eta_{W^R e}}\frac{w^R R}{pQ+p^*Q^*}+\overline{\eta_{W^N e}}\frac{w^N N}{pQ+p^*Q^*}\right)\right] \tag{20}$$

where χ denotes the export ratio to the total revenue, which is defined as $p^*Q^*/(pQ+p^*Q^*)$; η_{pe} denotes the exchange rate elasticity of domestic price, i.e., $\frac{\partial p}{\partial e}\frac{e}{p}$; and η_{p*e} denotes the exchange rate elasticity of foreign price. The elasticities η and η^* are the price elasticities in domestic and foreign demands respectively, which have been already defined in Equation 12. The $\varepsilon_{\eta e}$ and $\varepsilon_{\eta^* e}$ are respectively the exchange-rate elasticity of markups in domestic and foreign markets, i.e., $\frac{\partial \mu}{\partial e}\frac{e}{\mu}$ and $\frac{\partial \mu^*}{\partial e}\frac{e}{\mu^*}$. $\overline{\eta_{w^R e}}$ denotes the exchange-rate elasticity of regular workers' wage without distinguishing between domestic and international markets, while $\overline{\eta_{w^N e}}$ denotes the exchange-rate elasticity of non-regular workers' wage.

The first term in the square brackets in Equation 20 captures a channel for domestic sales. The sign of this term is determinate when the magnitude of η, the domestic price elasticity, is large (less than minus one), while in other cases, its sign is not determinate. As e increases (as Yen depreciates), domestic prices rise especially for goods that we have relied on imports (e.g. raw materials), which results in a positive exchange rate elasticity of price in the domestic market $\eta_{pe} > 0$. In addition, $\varepsilon_{\eta e}$, the exchange-rate elasticity of markups in domestic market is positive, i.e., $\varepsilon_{\eta e} > 0$, since the domestic price increases due to the increase in e. As defined earlier, $1/\mu_t$ is the mark-up ratios in the domestic product market, thus it is positive. In sum, if domestic demand is elastic, i.e., $\eta < -1$, the effect of an increase in e on $\frac{\partial \pi}{\partial R}$ is negative within the channel of domestic sales. In other words, the increase in domestic product prices induced by a currency depreciation largely decreases the quantity sold (if $\eta < -1$), which causes a fall of domestic sales revenue, and the flow of regular workers decreases.[4]

The second term in the square brackets in Equation 20 captures a channel for foreign market

[3]The calculation is in the Appendix.

[4]Of course, if the domestic demand curve is inelastic, the opposite thing will occur (Nucci and Pozzolo 2001).

sales. $\eta_{p^*e} = -1$ means a complete pass-through to foreign prices of an exchange-rate change, while $\eta_{p^*e} = 0$ means no path-through, and thus η_{p^*e} ranges from minus one to zero.[5] ε_{η^*e} is again positive for the same reason above. Apart from the case with the channel for domestic sales, if the price elasticities of foreign demand is very elastic, an increase in e contributes to increasing $\frac{\partial \pi}{\partial R}$. In other words, the fall in foreign product prices induced by a currency depreciation increases the quantity sold greatly (i.e., $\eta^* < -1$) in the foreign product markets, which causes an increase of foreign sales revenue, and the flow of regular workers increases.[6]

The third channel captures the costs. When e rises, this can change wages of regular and non-regular workers' nominal wages, which results in nonnegative elasticity of workers' wages, making this third term nonnegative.

On the other hand, holding other things constant, since firms with lower product market power have μ and μ^* close to zero in Equation 20, they react more significantly to the exchange-rate shift.

Thus, what we can say about the sign and magnitude of $\partial \Delta R / \partial e$ is that it really depends on the magnitude of price elasticity (whether $\eta < -1$ or not) in the first two channels in Equation 20. Thus, the sign of $\frac{\partial^2 \pi}{\partial R \partial e}$ is indeterministic. The more it becomes elastic, the more negative the response of ΔR to e is likely to become.

Next, we will focus on the flow of the number of non-regular workers. According to Equation 19, the second term is unambiguously positive because $\eta_{pe} > 0$ and $F_{NN} < 0$. The sign of the first term depends on the elasticity of demand curve. Since the elasticity of workers' wages is non-negative, if the demand curve is elastic (i.e., $\eta^* < -1$), the first term is unambiguously negative. In other words, the less elastic the domestic demand curve is, the less likely the depreciation of the currency leads to the cut of non-regular workers. This result is the same as that of the regular workers, but the condition that determines the sign of Equation 19 is the elasticity of demand curve only, in the case of non-regular workers, while conditions determining the flow of regular workers are much more complex. In other words, the flow of non-regular workers can be very high or low without many conditions satisfied at the same time.

[5] For more details, see Nucci and Pozzolo (2001).

[6] Again, if the domestic demand curve is inelastic, the opposite thing can occur (Nucci and Pozzolo 2001).

Then, the response of regular and non-regular workers' flows to a change in exchange rates can be summarized as follows: (1) If price elasticity of demand in domestic product markets is largely negative, as Yen depreciates, the flow of regular workers decreases. This result is the same as the case of non-regular workers, but conditions determining the flow of non-regular workers are much simpler than those of regular workers. Thus, the flow of non-regular workers can be influenced more easily by the elasticity of demand curve than that of regular workers. (2) The larger the markup is, the smaller the reaction becomes, which implies that firms with large power is unlikely to face a large fluctuation in the number of regular workers in response to the change in exchange rate. (3) The regular-worker flows decrease when the discount factor β is small, and the natural rate of job separation, δ, is high, since the expected present value of the "investments" becomes low in these cases. (4) The regular-worker flows greatly decrease when the exchange-rate elasticity of regular and non-regular workers' wages is large under the depreciation of the currency. (5) The regular-worker flows greatly decrease when labor costs ratio compared to outputs is large under the depreciation of the currency.

3 Empirical Model

3.1 Model

This section introduces the empirical model to estimate how the fluctuation in the exchange rate influences the change in employment of a firm via the change in imports and exports. Slightly modifying Nucci and Pozzolo (2010), the empirical model for the labor adjustment according to the fluctuation in the exchange rate is as follows:

$$\begin{aligned}\%\Delta Y_{ijt} = \beta_0 + \beta_1 Imp_{it-1}\%\Delta E_t + \beta_2 Exp_{it-1}\%\Delta E_t + \beta_3 Imp_{it-1} + \beta_4 Exp_{it-1} \\ +\beta_5 Markup_i\,(+\beta_6 \ln Y_{ijt-1}) + d_{jt}\,(+c_i) + u_{ijt},\end{aligned} \tag{21}$$

where $\%\Delta Y_{ijt}$ is the percentage change in the outcome variables that are the total sales, the number of regular or non-regular employees of firm i in industry j in year t. The percentage change of an outcome variable is defined as $(Y_{ijt} - Y_{ijt-1})/[(Y_{ijt} + Y_{ijt-1})/2]$ to allow for zero values. Imp_{it-1} is the share of imported inputs among all intermediate inputs, and Exp_{it-1} is the share of export sales among all sales. The term $\%\Delta E_t$ is the percentage change in the real effective exchange rate, the amount of foreign currency units to 100 Yen, and thus its increase corresponds to Yen appreciation. The variable $Markup_i$ is defined as the sample-period average of (Total sales - Sales cost)/Total sales. The model includes the industry (17 categories) $\times$ year fixed effects, d_{jt}, to control for time-variant industry-specific factors, such as product and input prices. By including these fixed effects, the effects of the exchange-rate fluctuation on sales or employment are identified off the firm heterogeneity of trade exposure within an industry $\times$ year cell. The linear term of $\ln E_t$ is not included, because the effect is captured by the industry $\times$ year fixed effects.

The estimation equation expresses the difference-in-differences estimation. The change in the exchange rate affects the employment of importing and exporting firms, but it does not affect the employment of firms with neither imports nor exports; firms exposed to international trade serve as a treatment group, and firms not exposed to international trade serve as a control group. Thus the error term u_{it} is not correlated with the treatment status, Imp_{it-1} or Exp_{it-1}, if firms with and without international trade exposures share the same unobserved factors determining the employment adjustment. To make this exogeneity assumption plausible, we allow for industry $\times$ year specific shocks. Thus the comparison of high-exposure firms and low-exposure firms is made within an industry $\times$ year cell. Given the exogeneity assumption,

$$E(u_{ijt}|Imp_{it-1}, Exp_{it-1}, \Delta \ln E_t, Markup_{it}, d_{jt}) = 0,$$

the OLS estimator is an unbiased and consistent estimator.

We first confirm the validity of the specification by using total sales as the dependent variable. The appreciation of Yen – an increase in $\ln E_t$ – is supposed to increase the total sales of importing firms through cost reduction; thus, we expect β_1 to be positive. In contrast, the appreciation of Yen is supposed to decrease the total sales of exporting firms through the increase of product price; thus we expect the coefficient β_2 to be negative. After confirming the validity of the specification, we proceed to examine the effect of the exchange-rate fluctuation on the adjustment of regular and non-regular workers.

In the estimation of employment equations, we include lagged regular employment, $\ln Y_{ijt-1}$, as an additional explanatory variable to capture the effect of the state variable on employment adjustment, as expressed by Equation 21.

The choice of invoice currency has a subtle impact on the estimation, but it does not affect the expected sign of the coefficient. The appreciation of Yen, for example, decreases the total sales of exporting firms through the reduction of export quantity if the invoice currency is Yen, because the product price in local currency increases given a positive pass-through; whereas it decreases the total sales of exporting firms through price reduction if the invoice currency is foreign currency, because the Yen amount received for a foreign currency decreases, again, given a positive pass-through. Ito et al. (2012) document that Japanese firms tend to use US dollars and Euros for trade with the US or European countries, respectively, and they use US dollars as the invoice currency even for trade with Asian countries. According to them, as of the second half of 2008, the share of Yen invoicing is 39.4% in Japanese exports to the world and 20.7% in Japanese imports from the world.

We decompose the change in the exchange rate into trend and transitory components and estimate the employment response to a permanent change of the exchange rate by estimating the equation by the instrumental variable method, using the trend component of the exchange rate as the instrumental variable. Using the Beverage and Nelson decomposition (Beveridge and Nelson 1981), we first elicit the trend component in the exchange rate. Then, the elicited trend component interacted with import/export shares serve as the instrumental variables for the endogenous variables: the interactions of the percentage change in the exchange rate and the import/export shares in Equation 21. The IV estimate is the employment response to the permanent change in the exchange rate, as the literature on the local average treatment effect suggests (Angrist and Imbens

1994, Angrist et al. 1996).

We further allow for firm-level fixed effects, c_i, in the estimation of the sales equation to allow for the possible correlation of an unobserved firm-specific growth factor with the firm's import or export dependence. Recent literature emphasizes both theoretically and empirically that firms with high productivity tend to engage in international trade, because only these firms can recoup the fixed cost of engaging in such trade. Although the productivity heterogeneity in levels is differenced out in the specification, heterogeneity in the growth rate may create a spurious correlation between high sales growth and heavy dependence on international trade. We address this concern by examining whether allowing for unobserved growth determinants changes the estimation results significantly.

4 Data

This study uses the Basic Survey of Japanese Business Structure and Activities, published by the Ministry of Economy, Trade, and Industry of the Japanese government. The Basic Survey of Japanese Business Structure and Activities is a panel survey of firms conducted at each year covering firms that hire 50 employees or more, hold stated capital (or contribution) of at least 30 million Yen and operate in following industries: mining, manufacturing, public utility, communication, wholesale and retail, finance and insurance, real estate and leasing, academic research and professional service, lodging and restaurant, daily-living service and leisure, education and miscellaneous services. The survey was first launched in 1992, but it started asking the number of workers from temporary help agencies from 2001. Thus, this study uses data from 2001 to 2012, covering the period during which the global financial crisis took place.

We constructed the variables used for this study as follows. The number of employees is the number of executives with compensation and permanent employees. A permanent employee is defined as an employee with a contract period that extends one month or longer, or an employee who worked 18 days or more in each of past two months. The permanent employee includes several classifications of workers, such as *Seishain, Seishokuin, Part, Arubaito, Shokutaku, Keiyakushain*. The number of permanent employees is divided into the number of regular workers (*Seishain* and *Seishokuin*) and part-time workers who work fewer hours per day than a regular worker, or a worker who works fewer days per a week than a regular worker. The survey further asks for the number of temporary workers with a contract period that extends less than one month and the number of workers dispatched from temporary help agencies. Regular workers (*Seishain* and *Seishokuin*) typically work full-time with an indefinite contract. We define non-regular workers as the sum of part-time workers, temporary workers with contract periods extending less than one month, and workers dispatched from temporary help agencies. Although Japanese labor law does not explicitly provide differential degrees of employment protection between regular and non-regular employment, court precedents conventionally endow stronger protection for regular employees than for non-regular employees (Asano et al. 2013).[7]

We construct each firm's exposure to international trade by the amount of imports among total purchases and the amount of exports among total sales. The amounts of imports and exports record the respective amounts that the firm directly clears through customs. We calculate market power using the Lerner index: (Total sales−Operating cost)/Total sales.[8] The Lerner index corresponds to the degree of price markup.

Table 1 reports the descriptive statistics of the firm-level panel data. The average import share – the fraction of imports among all purchases – is 0.043, with standard deviation of 0.148. The average export share – the fraction of exports among total sales – is 0.027, with standard deviation of 0.099. Among all firm-year observations, 22% record a positive export share and 22% record a positive import share. The distributions of import and export shares are drawn in Figure 2 given positive shares. Both distributions have a long right tail; many firms do not engage in international trade, but a few firms actively engage in it. This heterogeneity of exposure to international trade

[7]The famous court precedent that clearly endows non-regular workers with weaker employment protection over regular workers is the Hitachi Medico Case. In this case, the Supreme Court demonstrated that it is not unreasonable to terminate a worker with a fixed term contract in advance of regular employees when there is economic redundancy (Takeuchi-Okuno 2010).

[8]The operating cost includes cost of sales and services and selling and administrative expenses.

assures the validity of the difference-in-differences estimation strategy employed in this paper. The correlation coefficient of import and export shares is 0.243; the firms engaging in import trade are more likely to engage in export trade. The average market power approximated by the Lerner index is 0.033, whereas its standard deviation is 0.044.

Decomposing firms into four types by their involvement in import and export sheds light on the heterogeneity of firms among types. Firms involved in international trade are larger in terms of sales, operating cost, and regular employment size; and this tendency applies more to exporting firms than to importing firms. The market power, approximated by (Total sales - Operating cost)/Total sales, is higher among exporting firms than other firms; the evidence is consistent with empirical regularities found in existing studies that firms with high productivity tend to export. Those firms involved in international trade, particularly exporting, tend to rely less on non-regular employment.

We use a broad index of the real effective exchange rate (REER) constructed by the Bank of International Settlement (BIS) as the measure of the exchange rate. The BIS REER is the geometric average of exchange rates of Yen for a unit of multiple currencies using the lagged trade volume as the weight. For example, the weight basket for Japan between 2008 and 2010 includes China (29.5%), the US (16.6%), Euro area (14.0%), Korea (5.9%), Chinese Taipei (3.8%), Thailand (3.6%), and Singapore (2.8%), followed by the UK, Canada, and Australia. We draw on the broad index regardless of the fact that the US dollar or the Euro are dominant invoice currencies, because the exchange rates between local currencies and the invoice currencies eventually determine the trade flows as well. Figure 1 draws the time series of the REER and suggests that the foreign exchange fluctuations are sufficiently large throughout the sample period.

We decompose the change in the exchange rate into permanent and transitory components using the Beveridge-Nelson decomposition (Beveridge and Nelson 1981). The Beveridge-Nelson decomposition method first applies the autoregressive (AR) model to the first-differenced exchange-rate series. Then the temporary shock predicted to affect the variable in the far (infinite) future is classified as the trend component (the sum of deterministic and stochastic trends), and the rest is classified as the cyclical component. We estimated the AR(2) model based on Bayesian Information Criterion. Figure 3 draws the results of the decomposition, showing that the much of the variation in the exchange rate is attributable to the trend component.

The Basic Survey of Japanese Business Structure and Activities had asked about the firm's situation on June 1 until 2006 and on March 31 from 2007. We match an annual average of REER prior to the survey: The average of REER between June of year $t-1$ and May of year t is matched until 2006, and it is matched between April of year $t-1$ and March of year t from 2007.

5 Empirical Results

5.1 The effects on total sales

Table 2 shows the regression results looking at the impact of the exchange-rate fluctuation on the total sales change. The coefficients of interest pertain to the interaction terms between the percentage change in the exchange rate and the import and export shares in the previous year. The OLS result reported in the first column shows that the coefficient of the interaction between the exchange-rate fluctuation and the import share is not statistically significant. This means that Yen appreciation does not increase the total sales of importing firms. The reason why Yen appreciation does not increase the total sales of importing firms is not clear, but we speculate that importing firms do not expand production in response to cost reduction, because either they face inelastic domestic product demand or non-importing firms similarly benefit from the decrease of purchase cost. One might think that the effect of the exchange-rate fluctuation cancels out in the case of firms involved in both import and export activities. To address this concern, we implement a subsample analysis that excludes exporting firms, but we find that Yen appreciation does not affect sales even in the subsample that excludes exporting firms.

Yen appreciation reduces the total sales of exporters as the negative coefficient for the interaction term of the exporting share and the increase of the exchange rate. A 10% appreciation of Yen reduces total sales by 0.826% for firms that export 10% of total sales, according to the OLS estimate reported in the first column; the estimated coefficient is statistically significant at the 5% level. The contrasting results on the effects of the exchange-rate fluctuation on sales between importers and exporters are not surprising, because the effect of the exchange rate on sales among importers is through the production cost reduction, and thus it is not as direct as the effect among exporters, where the exchange rate directly affects sales through price or quantity channels.

The fixed-effects estimates reported in the second column show that the estimates on the exchange-rate fluctuation do not change significantly even after allowing for unobserved growth heterogeneity across firms. The change of coefficients on the linear terms of import and export shares implies that the unobserved growth factor is negatively correlated with the import share and positively correlated with the export share; the results imply that exporting firms grow faster than importing firms during the analysis period of 2001-2012. This finding is not surprising, given that the sample period covers the long-term Yen depreciation period that started in the early 2000s and ended in 2007, the right before the outbreak of the global financial crisis. In the end, however, similar estimated coefficients on the interaction terms imply that allowing for the unobserved growth rate is not necessary for our purpose.

The estimates based on the instrumental variable method, using the trend component of the exchange-rate fluctuation as the IV, appears in the third column in Table 2. The absolute size of the coefficients on the interaction term of the export share and the exchange rate fluctuation becomes about 9% larger, from -0.826 to -0.904, compared with the OLS results. This increase of the estimated coefficient implies that firms' sales amounts react more to the permanent change of the exchange rate than to the temporary change of the exchange rate.

The results of the fixed-effects instrumental variable estimation appear in the fourth column. The estimated coefficients for the interaction terms of import/export shares and the change of the exchange rate becomes slightly larger than the results without firm-fixed effects. The changes of the size of coefficients, however, are quantitatively limited. For example, the coefficient on the interaction term of the export share and the exchange-rate fluctuation increases by about 3%, from -0.904 to -0.935. From this minor change in the estimation results, we argue that the estimated effects of exchange-rate fluctuations on importers and exporters are not biased because of an unobserved firm-specific growth factor. Accordingly, we do not explicitly consider the effects of unobserved heterogeneity in the subsequent employment analysis.

Overall, we confirm that Yen appreciation reduces the total sales of exporters across various specifications. This robust finding assures that our empirical framework captures the demand shock to a firm caused by the exchange-rate fluctuations through the exporting channel. We now examine how the product demand shock caused by the exchange-rate fluctuation is transmitted to the employment adjustment.

5.2 The effects on regular workers

We next examine the effect of the exchange-rate fluctuation on the adjustment of regular workers. The first two columns of Table 3 tabulate the regression results of the percentage change in regular employment on the exchange-rate fluctuation interacted with each firm's dependence on international trade and other covariates. The first and second columns report the instrumental variable estimation results that use the two-year-lagged employment as the instrumental variable for the one-year-lagged employment. The first column reports the estimation result without instrumenting the exchange-rate fluctuation. The signs of the estimated coefficients are consistent with the signs of the total sales regression; Yen appreciation does not affect the employment of regular workers of importers but reduces that of exporters. A 10% appreciation of Yen decreases the number of regular workers by 0.161% among firms that export 10% of total sales. To compare this estimate with existing estimates of wage elasticity of labor demand, consider a firm that exports 100% of its total sales. Fixing the product price in a foreign currency, an appreciation of Yen induces the fall of the product price measured in Yen and thus implies an increase in the real wage, while the product price fall increases both the real wage and the real rental costs, whereas a nominal wage rise increases only the real wage without changing the real rental cost. The estimated elasticity 0.161 is smaller than the consensus estimate of the labor demand elasticity, which is 0.30 in the literature, but this is plausible given the absence of the substitution to capital.

The estimated coefficients on explanatory variables other than the exchange-rate fluctuation are consistent with the estimation results for the sales-change equation reported in Table 2. Importing firms are on a declining trend, whereas exporting firms are on an ascending trend in terms of regular employment during the sample period between 2001 and 2012. The long-term Yen depreciation trend from 2000 to 2007 –right before the outbreak of the global financial crisis– as shown in Figure 1 does not contradict the decline of importing firms and the growth of exporting firms. These findings suggest that the actual exchange-rate fluctuation, including the trend component extracted from it, does not fully capture firms' expectation for future exchange-rate fluctuation. The positive coefficient for the average market power, each firm's average of the price-cost margin during the sample period, implies that those firms with higher market power increased permanent employment more than those firms without market power. A one-percentage-point increase in the price-cost margin, whereas the average of the price-cost margin is 3.3%, as shown in Table 1, increases the regular employment growth rate by 0.283%. Theory predicts that firms with market power react less to the exchange-rate fluctuation. To test this prediction, we implemented a subsample analysis dividing the sample by the criterion of whether the firm's average market power is above or below the median of the average market power distribution. We, however, did not find a significant difference in the estimated elasticities by the subsamples.

The coefficient on the lagged natural log of the number of regular workers is -0.004, implying the mean reversion of the regular employment adjustment. Since both the dependent and independent variables contain lagged employment, the OLS estimator would be biased downward if the lagged employment is subjected to measurement error. To deal with this problem, the lagged variable is instrumented by the 2-year lagged variable, and thus the estimates are free from the bias, given that the AR(1) structure fully captures the time series property of the employment adjustment process and no serial correlation is left in the error term.

Instrumenting the exchange-rate fluctuation with the trend component increases the estimated response of exporters by about 7% from -0.161 to -0.173 compared with the estimate without instrumenting the exchange-rate fluctuation, as reported in the second column in Table 3; the trend components of the exchange-rate fluctuation affects regular employment more significantly than the mixture of trend and transitory components. This finding is consistent with the theoretical prediction that firms adjust regular employment more to a permanent change in the exchange rate, taking the adjustment cost into consideration. The estimated coefficients on explanatory variables other than the exchange-rate fluctuation do not change from the results without instrumenting the exchange-rate fluctuation, as reported in Column 1 of Table 3.

5.3 The effects on non-regular workers

We next examine the effect of the exchange-rate fluctuation on the adjustment of non-regular workers. The third and fourth columns of Table 3 tabulate the regression results of the percentage change in non-regular employment on the exchange-rate fluctuation interacted with each firm's dependence on international trade and other covariates. Note that the number of observations is smaller than that used to estimate the regular employment equation, because the dependent variable is not well defined, and thus those observations with zero non-regular workers in two consecutive years are dropped from the estimation. The signs of the coefficients estimated without instrumenting the exchange-rate fluctuation reported in the third column are similar to the regular employment regression, but their magnitudes are quite different; Yen appreciation does not affect the number of non-regular workers of importers, but it reduces that of exporters. To take a firm that exports 10% of total sales as an example, a 10% appreciation of Yen decreases the number of regular workers by 0.854%; the size of coefficient is about 5 times larger than the regression coefficient for the number of regular workers reported in the first column of Table 3. This larger adjustment response implies that the adjustment cost of non-regular workers is significantly lower compared with that of regular workers. To repeat the same discussion introduced in the regular employment estimation, the estimated elasticity is closely related to the usual labor demand elasticity, because 100% depreciation of Yen and 100% increase of real wage have arguably similar impacts on employment neglecting the capital substitution and scale effect. The estimated elasticity of 0.854 is larger than the consensus estimate of the labor demand elasticity in the literature, around 0.3. Again, this large elasticity is consistent with a low adjustment cost of non-regular workers.

Estimated coefficients for other covariates are also worth mentioning. As pointed out before, 2001-2012 sample period covers the long-term Yen depreciation that ends at the global financial crisis in 2008. This long-term trend of Yen depreciation may well have created expectation on long-term depreciation that cannot be captured by actual exchange-rate movement. The negative coefficient on import and export shares imply that both importing and exporting firms had shrunk non-regular employment in this long-term trend. That importing firms were cutting non-regular employment in the process of long-term Yen depreciation seems natural, but that exporting firms were doing so may seem surprising at the first glance. These seemingly counterintuitive findings do not contradict the theoretical prediction, though. In the period of long-term Yen depreciation, exporting firms increased regular workers and decreased non-regular workers; these findings are consistent with the theoretical prediction that firms adjust regular workers in response to a permanent change in the exchange rate under the assumption that regular and non-regular workers are substitutable. Firms with higher average market power tend to increase non-regular employment as well as the regular employment. The coefficient on the lagged regular employment implies that the firms with higher level of lagged regular employment are more likely to increase the non-regular employment.

The estimation results where the exchange-rate fluctuation is instrumented with the trend component appear in the fourth column in Table 3. The estimated coefficient for the export share $\times$ the exchange-rate fluctuation shrinks by about 12% compared with the estimate obtained without instrumenting the exchange-rate fluctuation; the trend component of the exchange-rate fluctuation affects the number of non-regular workers in a less significant way than the temporary component of the exchange-rate fluctuation. This IV estimate implies that exporters rely on non-regular workers for the employment adjustment to the temporary exchange-rate shock and that they adjust permanent employment in response to the permanent exchange-rate shock. How this adjustment behavior contrasts with the permanent change in exchange-rate is consistent with a substantial difference in the adjustment cost of regular and non-regular workers. The estimated coefficients other than the exchange-rate fluctuation are almost identical to the estimation results without instrumenting the exchange-rate fluctuation.

Non-regular workers are further classified into several categories based on the difference in the criteria used to define non-regular workers, such as work hours, length of contract period, whether a worker is employed by the workplace or a temporary help agency, and the career-track classification (*Seishain/Seishokuin* or other categories, as pointed out by Kambayashi and Kato (2013) and Asano et al. (2013). Our definition of non-regular workers includes three categories: permanent employee with part-time status, temporary employees, and workers hired by temporary help agencies. To shed light on the heterogeneity of the employment adjustment process among non-regular workers, we estimate the same model using each detailed definition of non-regular workers as the dependent variable. The estimation results do not render a systematic pattern because of the smaller sample size for each category, and perhaps more importantly, firms use these three categories of non-regular employment interchangeably to absorb temporary exchange-rate shocks.

6 Conclusion

We identify the impact of the exchange-rate fluctuation on the employment adjustment, conceptually implementing a difference-in-differences estimation, employing unique firm-level panel data that record accurate employment information and measures of each firm's exposure to international trade. We confirm that the appreciation of Yen decreases the employment of exporting firms. The sensitivity of adjustment of the number of non-regular workers to the exchange-rate fluctuation is about 5 times larger than that of the number of regular workers. The difference in the adjustment sensitivity implies a significantly lower adjustment cost of non-regular workers compared with regular workers to exogenous demand shocks created by the exchange-rate fluctuation. Firms adjust the regular workers to the permanent exchange-rate shock more significantly than to the temporary exchange-rate shock, whereas firms adjust non-regular workers more significantly to the temporary shock than to the permanent shock.

We contribute to the literature in several ways. First, we first show that stabilizing the exchange rate contributes to stabilizing employment, particularly that of non-regular workers. Credible evidence on the effect of the exchange-rate fluctuation on employment relying on firms' heterogeneous dependence on international trade is limited, except for the results based on Italian firm-level panel data by Nucci and Pozzolo (2010), who do not distinguish between regular and non-regular workers. Second, we identify the difference of adjustment costs between regular workers and non-regular workers, using the exchange fluctuation as a credible exogenous source of a labor-demand shifter. This finding gives support for the claim that firms use non-regular workers as a buffer of employment adjustment because of their lower adjustment cost.

The estimation results suggest a moderate effect of exchange-rate stabilization on employment stabilization: To take a firm that exports 10 % of total sales as an example, a 10 % appreciation of Japanese Yen decreases the regular employment of the firm by 0.161%. Although the average impacts seem moderate, given the large heterogeneity in the exposure to international trade, the impacts are quite different across firms. Moreover, the effect of the exchange-rate fluctuation affects non-regular workers more than regular workers; the impact on the non-regular workers is about 5 times as large as the impact on the regular workers. Therefore, policy makers should pay careful attention to the heterogeneous impact of the exchange-rate fluctuation on employment across firms and workers.

Improving the measurement of permanent and temporary components of the exchange-rate fluctuation is left for future research. To decompose the permanent and temporary exchange-rate fluctuation, we rely on the Beveridge and Nelson decomposition method, which is a univariate decomposition method that extracts the time-series properties of the exchange rate without imposing restrictions implied by economic theory. Extraction of permanent and temporary shocks to the exchange rate by the Blanchard and Quah (1989) – a decomposition method to a bivariate system of the exchange rate and the current account – and using them to analyze the impacts of permanent or transitory exchange-rate fluctuations on labor market outcomes are left for future research.

Appendix

To derive the expression of Equation 18, we first utilize the expression of $\partial\pi/\partial R$ and then differentiate it with respect to e. Those are the overall steps to be taken, but just for preparation, before moving on to the differentiation of $\partial\pi/\partial R$, we derive the expression of F_R utilizing the equation of π/R. To simplify the notation we have dropped all time indices.

$$
\begin{aligned}
\frac{\pi}{R} &= \frac{Qp+eQ^*p^*}{R} - w^R - w^N\frac{N}{R} && \text{(A.1)}\\
&= \frac{Qp+eQ^*p^*}{R} - w^R - p\Big(1+\frac{1}{\eta}\Big)F_N\frac{N}{R} && \text{(A.2)}\\
&= \frac{Qp+eQ^*p^*}{R} - w^R - p\Big(1+\frac{1}{\eta}\Big)\frac{F-F_RR}{N}\frac{N}{R} && \text{(A.3)}\\
&= \frac{Qp+eQ^*p^*}{R} - w^R - p\Big(1+\frac{1}{\eta}\Big)\Big(\frac{Q+Q^*}{R}-F_R\Big) && \text{(A.4)}\\
p\Big(1+\frac{1}{\eta}\Big)F_R &= \frac{\pi}{R} - \frac{Qp+eQ^*p^*}{R} + w^R + p\Big(1+\frac{1}{\eta}\Big)\frac{Q+Q^*}{R} && \text{(A.5)}
\end{aligned}
$$

From Equation 14:

$$
\frac{\partial\pi}{\partial R} = -w^R + p\Big(1+\frac{1}{\eta}\Big)F_R. \tag{A.6}
$$

Next, we substitute $p\Big(1+\frac{1}{\eta}\Big)F_R$ in Equation (A.5) into Equation 14 (or equivalently, Equation (A.6)), which yields the following expression:

$$
\begin{aligned}
\frac{\partial\pi}{\partial R} &= \frac{\pi}{R} - \frac{Qp+eQ^*p^*}{R} + p\Big(1+\frac{1}{\eta}\Big)\frac{Q+Q^*}{R} && \text{(A.7)}\\
&= \frac{Qp+eQ^*p^*-w^RR-w^NN}{R} - \frac{Qp+eQ^*p^*}{R} + p\Big(1+\frac{1}{\eta}\Big)\frac{Q+Q^*}{R} && \text{(A.8)}\\
&= \Big(1+\frac{1}{\eta}\Big)\frac{pQ+pQ^*}{R} + \frac{-w^RR-w^NN}{R} && \text{(A.9)}\\
&= \frac{1}{R}\Bigg(pQ\big(1+\frac{1}{\eta}\big) + ep^*Q^*\big(1+\frac{1}{\eta^*}\big) - w^RR - w^NN\Bigg) && \text{(A.10)}\\
&= \frac{1}{R}\Bigg(pQ\frac{1}{\mu} + ep^*Q^*\frac{1}{\mu^*} - w^RR - w^NN\Bigg) && \text{(A.11)}
\end{aligned}
$$

To derive Equation 18 in the text, we differentiate (A.11) with respect to the exchange rate e.

$$\frac{\partial^2\pi}{\partial R\partial e} = \frac{1}{R}\left[\frac{\partial p}{\partial e}Q\frac{1}{\mu} + p\frac{\partial Q}{\partial p}\frac{\partial p}{\partial e}\frac{1}{\mu} - pQ\frac{1}{\mu^2}\frac{\partial \mu}{\partial e}\right] \tag{A.12}$$

$$+\frac{1}{R}\left[p^*Q^*\frac{1}{\mu^*} + e\frac{\partial p^*}{\partial e}Q^*\frac{1}{\mu^*} + ep^*\frac{\partial Q}{\partial p^*}\frac{\partial p^*}{\partial e}\frac{1}{\mu^*} - ep^*Q^*\frac{1}{\mu^2}\frac{\partial \mu^*}{\partial e}\right]$$

$$+\frac{1}{R}\left[-\frac{\partial w^R}{\partial e}R - \frac{\partial w^N}{\partial e}N\right]$$

$$= \frac{1}{R}\left[\frac{\partial p}{\partial e}\frac{e}{p}\frac{p}{e}Q\frac{1}{\mu} + p\frac{\partial Q}{\partial p}\frac{p}{Q}\frac{Q}{p}\frac{\partial p}{\partial e}\frac{e}{p}\frac{p}{e}\frac{1}{\mu} - pQ\frac{1}{\mu^2}\frac{\partial \mu}{\partial e}\frac{e}{\mu}\frac{\mu}{e}\right] \tag{A.13}$$

$$+\frac{1}{R}\left[p^*Q^*\frac{1}{\mu^*} + e\frac{\partial p^*}{\partial e}\frac{e}{p^*}\frac{p^*}{e}Q^*\frac{1}{\mu^*} + ep^*\frac{\partial Q^*}{\partial p^*}\frac{p^*}{Q^*}\frac{Q^*}{p^*}\frac{\partial p^*}{\partial e}\frac{e}{p^*}\frac{p^*}{e}\frac{1}{\mu^*} - ep^*Q^*\frac{1}{\mu^{*2}}\frac{\partial \mu^*}{\partial e}\frac{e}{\mu^*}\frac{\mu^*}{e}\right]$$

$$+\frac{1}{R}\left[-\frac{\partial w^R}{\partial e}\frac{e}{w^R}\frac{w^R}{e}R - \frac{\partial w^N}{\partial e}\frac{e}{w^N}\frac{w^N}{e}N\right]$$

$$= \frac{1}{Re}\left[\frac{\partial p}{\partial e}\frac{e}{p}pQ\frac{1}{\mu} + pQ\frac{\partial Q}{\partial p}\frac{p}{Q}\frac{\partial p}{\partial e}\frac{e}{p}\frac{1}{\mu} - pQ\frac{\partial \mu}{\partial e}\frac{e}{\mu}\frac{1}{\mu}\right] \tag{A.14}$$

$$+\frac{1}{Re}\left[ep^*Q^*\frac{1}{\mu^*} + e\frac{\partial p^*}{\partial e}\frac{e}{p^*}p^*Q^*\frac{1}{\mu^*} + ep^*Q^*\frac{\partial Q^*}{\partial p^*}\frac{p^*}{Q^*}\frac{\partial p^*}{\partial e}\frac{e}{p^*}\frac{1}{\mu^*} - ep^*Q^*\frac{\partial \mu^*}{\partial e}\frac{e}{\mu^*}\frac{1}{\mu^*}\right]$$

$$+\frac{1}{Re}\left[-\frac{\partial w^R}{\partial e}\frac{e}{w^R}w^RR - \frac{\partial w^N}{\partial e}\frac{e}{w^N}w^NN\right]$$

$$= \frac{pQ+p^*Q^*}{Re}\frac{pQ}{pQ+p^*Q^*}\frac{1}{\mu}\left[\frac{\partial p}{\partial e}\frac{e}{p} + \frac{\partial Q}{\partial p}\frac{p}{Q}\frac{\partial p}{\partial e}\frac{e}{p} - \frac{\partial \mu}{\partial e}\frac{e}{\mu}\right] \tag{A.15}$$

$$+\frac{epQ+ep^*Q^*}{Re}\frac{ep^*Q^*}{epQ+ep^*Q^*}\frac{1}{\mu^*}\left[1 + \frac{\partial p^*}{\partial e}\frac{e}{p^*} + \frac{\partial Q^*}{\partial p^*}\frac{p^*}{Q^*}\frac{\partial p^*}{\partial e}\frac{e}{p^*} - \frac{\partial \mu^*}{\partial e}\frac{e}{\mu^*}\right]$$

$$-\frac{pQ+p^*Q^*}{Re}\left[\frac{\partial w^R}{\partial e}\frac{e}{w^R}\frac{w^RR}{epQ+ep^*Q^*} + \frac{\partial w^N}{\partial e}\frac{e}{w^N}\frac{w^NN}{epQ+ep^*Q^*}\right]$$

$$= \frac{pQ+p^*Q^*}{Re}\frac{pQ}{pQ+p^*Q^*}Re\frac{1}{\mu}\left[\eta_{pe} + \eta\eta_{pe} - \varepsilon_{\eta e}\right] \tag{A.16}$$

$$+\frac{pQ+p^*Q^*}{Re}\frac{pQ}{pQ+p^*Q^*}Re\frac{1}{\mu^*}\left[\eta_{p^*e} + \eta^*\eta_{p^*e} + 1 - \varepsilon_{\eta^*e}\right]$$

$$-\frac{pQ+p^*Q^*}{Re}\left[\overline{\eta_{W^Re}}\frac{w^RR}{pQ+p^*Q^*} + \overline{\eta_{W^Ne}}\frac{w^NN}{pQ+p^*Q^*}\right]$$

$$\frac{\partial^2 \pi}{\partial R \partial e} = \frac{pQ + p^*Q^*}{Re} \frac{1}{\mu} (1-\chi) \left(\eta_{pe}(1+\eta) - \varepsilon_{\eta e} \right) \tag{A.17}$$

$$+ \frac{pQ + p^*Q^*}{Re} \frac{1}{\mu^*} \chi \left(\eta_{p^*e}(1+\eta^*) + 1 - \varepsilon_{\eta^* e} \right)$$

$$- \frac{pQ + p^*Q^*}{Re} \left(\overline{\eta_{W^R e}} \frac{w^R R}{pQ + p^*Q^*} + \overline{\eta_{W^N e}} \frac{w^N N}{pQ + p^*Q^*} \right)$$

$$= \frac{pQ + p^*Q^*}{Re} \left[\frac{1}{\mu} (1-\chi) \left(\eta_{pe}(1+\eta) - \varepsilon_{\eta e} \right) + \frac{1}{\mu^*} \chi \left(\eta_{p^*e}(1+\eta^*) + 1 - \varepsilon_{\eta^* e} \right) \right. \tag{A.18}$$

$$\left. - \left(\overline{\eta_{W^R e}} \frac{w^R R}{pQ + p^*Q^*} + \overline{\eta_{W^N e}} \frac{w^N N}{pQ + p^*Q^*} \right) \right]$$

To derive the partial derivative of N with respect of e, we differentiate Equation 13 with respect of e.

$$\frac{\partial p}{\partial e} \frac{e}{p} \frac{p}{e} \left(1 + \frac{1}{\eta} \right) F_N + p \left(1 + \frac{1}{\eta} \right) F_{NN} \frac{\partial N}{\partial e} = \frac{\partial w^N}{\partial e} \frac{e}{w^N} \frac{w^N}{e} \tag{A.19}$$

$$\eta_{pe} \frac{p}{e} \left(1 + \frac{1}{\eta^*} \right) F_N + p \left(1 + \frac{1}{\eta} \right) F_{NN} \frac{\partial \Delta N}{\partial e} = \overline{\eta_{W^N e}} \frac{w^N}{e} \tag{A.20}$$

$$\frac{\partial \Delta N}{\partial e} = \frac{\overline{\eta_{W^N e}} w^N - \eta_{pe} p \left(1 + \frac{1}{\eta} \right) F_N}{pe \left(1 + \frac{1}{\eta} \right) F_{NN}} = \frac{\overline{\eta_{W^N e}} w^N}{pe \left(1 + \frac{1}{\eta} \right) F_{NN}} - \frac{\eta_{pe} F_N}{e F_{NN}} \tag{A.21}$$

References

Angrist, J., Imbens, G., 1994. Identification and estimation of local average treatment effects. Econometrica 62 (2), 467–475.

Angrist, J., Imbens, G., Rubin, D., 1996. Identification of causal effects using instrumental variables. Journal of the American Statistical Association 91, 444–455.

Asano, H., Ito, T., Kawaguchi, D., 09 2013. Why Has the Fraction of Nonstandard Workers Increased? A Case Study of Japan. Scottish Journal of Political Economy 60 (4), 360–389.
URL http://ideas.repec.org/a/bla/scotjp/v60y2013i4p360-389.html

Beveridge, S., Nelson, C., 1981. New approach to decomposition of economic time series into permanent and transitory components with particular attention to measurement of the ‘business cycle’. Journal of Monetary Economics 7, 151–174.

Blanchard, O. J., Quah, D., September 1989. The Dynamic Effects of Aggregate Demand and Supply Disturbances. American Economic Review 79 (4), 655–73.
URL http://ideas.repec.org/a/aea/aecrev/v79y1989i4p655-73.html

Brunello, G., 1990. Real exchange rate variability and japanese industrial employment. Journal of the Japanese and International Economies 4 (2), 121 – 138.
URL http://www.sciencedirect.com/science/article/pii/088915839090002N

Campa, J. M., Goldberg, L. S., 2001. Employment versus wage adjustment and the u.s. dollar. Review of Economics and Statistics 83, 477–489.

Dekle, R., 1998. The yen and japanese manufacturing employment. Journal of International Money and Finance 17 (5), 785 – 801.
URL http://www.sciencedirect.com/science/article/pii/S0261560698000266

Gourinchas, P.-O., 1999a. Exchange rates and jobs: What do we learn from job flows? In: NBER Macroeconomics Annual 1998, volume 13. National Bureau of Economic Research, Inc, pp. 153–222.
URL http://EconPapers.repec.org/RePEc:nbr:nberch:11247

Gourinchas, P.-O., 1999b. Exchange rates do matter: French job reallocation and exchange rate turbulence, 1984-1992. European Economic Review 43 (7), 1279 – 1316.
URL http://www.sciencedirect.com/science/article/pii/S0014292198001238

Hanagaki, T., Hori, M., 2015. The exchange rate and the performance of japanese firms: A preliminary analysis using firm-level panel data. Tech. rep., Economic and Social Research Institute, Cabinet Office, JAPAN.

Hijzen, A., Kambayashi, R., Teruyama, H., Genda, Y., 2015. The japanese labour market during the global financial crisis and the role of non-standard work: A micro perspective. Journal of the Japanese and International Economies 38, 260 – 281.
URL http://www.sciencedirect.com/science/article/pii/S0889158315000477

Holmlund, B., Storrie, D., 2002. Temporary work in turbulent times: The swedish experience. The Economic Journal 112 (480), pp. F245–F269.
URL http://www.jstor.org/stable/798374

Hosono, K., Takizawa, M., Tsuru, K., Feb. 2013. International Transmission of the 2008-09 Financial Crisis: Evidence from Japan. Discussion papers 13010, Research Institute of Economy, Trade and Industry (RIETI).
URL http://ideas.repec.org/p/eti/dpaper/13010.html

Houseman, S. N., 2001. Why employers use flexible staffing arrangements: Evidence from an establishment survey. Industrial and Labor Relations Review 55 (1), pp. 149–170.
URL http://www.jstor.org/stable/2696191

Hunt, J., 2000. Firing costs, employment fluctuations and average employment: An examination of germany. Economica 67 (266), pp. 177–202.
URL http://www.jstor.org/stable/2601441

Ito, T., Koibuchi, S., Sato, K., Shimizu, J., 2012. The choice of an invoicing currency by globally operating firms: A firm-level analysis of japanese exporters. International Journal of Finance & Economics 17 (4), 305–320.
URL http://dx.doi.org/10.1002/ijfe.1450

Kambayashi, R., Kato, T., 2013. Good jobs, bad jobs, and the great recession: Lessons from japans lost decade. Tech. rep., CEI Working Paper Series, No. 2013-01, Institute of Economic Research, Hitotsubashi University.

Klein, M. W., Schuh, S., Triest, R. K., March 2003. Job creation, job destruction, and the real exchange rate. Journal of International Economics 59 (2), 239–265.
URL http://ideas.repec.org/a/eee/inecon/v59y2003i2p239-265.html

Melitz, M. J., Redding, S. J., 2014. Chapter 1 - heterogeneous firms and trade. In: Elhanan Helpman, K. R., Gopinath, G. (Eds.), Handbook of International Economics. Vol. 4 of Handbook of International Economics. Elsevier, pp. 1 – 54.
URL http://www.sciencedirect.com/science/article/pii/B978044454314100001X

Moser, C., Urban, D., di Mauro, B. W., 2010. International competitiveness, job creation and job destruction: An establishment-level study of german job flows. Journal of International Economics 80 (2), 302 – 317.
URL http://www.sciencedirect.com/science/article/pii/S0022199609001196

Nucci, F., Pozzolo, A. F., 2001. Investment and the exchange rate: an analysis with firm-level panel data. European Economic Review 45, 259–283.

Nucci, F., Pozzolo, A. F., 2010. Exchange rate, employment and hours: what firm-level data say. Journal of International Economics 82, 112–123.

Nucci, F., Pozzolo, A. F., 2014. Exchange rate, external orientation of firms and wage adjustment. The World Economy 37 (11), 1589–1611.

OECD, 2014. Non-regular employment, job security and the labour market divide. In: OECD Employment Outlook 2014. OECD Publishing, Paris.

Takeuchi-Okuno, H., 2010. The regulation of fixed-term employment in japan. Japan Institute of Labor Policy and Training (ed): Labor policy on fixed-term employment contracts. Tokyo.

Tomiura, E., 2003. The impact of import competition on japanese manufacturing employment. Journal of the Japanese and International Economies 17 (2), 118 – 133.
URL http://www.sciencedirect.com/science/article/pii/S0889158303000133

Varejo, J., Portugal, P., 2007. Employment dynamics and the structure of labor adjustment costs. Journal of Labor Economics 25 (1), pp. 137–165.
URL http://www.jstor.org/stable/10.1086/509825

Table 1: Descriptive statistics of sample firms, 2001-2012

Variable	All	Non-import and non-export	Import but non-export	Export but non-import	Import and Export
Import share	0.043	0.000	0.220	0.000	0.178
	(0.148)	(0.000)	(0.297)	(0.000)	(0.243)
Export share	0.027	0.000	0.000	0.108	0.131
	(0.099)	(0.000)	(0.000)	(0.172)	(0.183)
Total sales	23,395	14,242	28,105	41,756	55,733
in million Yen	(168,838)	(91,583)	(162,218)	(287,834)	(312,537)
Operating cost	22,657	13,814	26,906	40,409	54,050
in million Yen	(165,462)	(89,884)	(152,157)	(284,160)	(306,975)
Market power	0.033	0.030	0.035	0.046	0.042
	(0.044)	(0.042)	(0.043)	(0.054)	(0.048)
Employment:	319.265	233.148	342.779	512.333	624.376
regular worker	(1,253.141)	(666.251)	(1,370.741)	(2,134.614)	(2,280.699)
Employment:	134.449	142.775	196.332	63.601	97.579
non-regular worker	(1,121.094)	(1,208.090)	(1,512.972)	(272.966)	(579.122)
Observations	322,849	228,204	23,825	22,456	48,364

Standard deviations are in parentheses. The import share is calculated by dividing the purchase turnover (total value of overseas purchase) by the purchase turnover (total transaction value). The export share is calculated by dividing the sales amount (total value of direct exports) by another variable: the sales amount (total transaction value). Operating cost is calculated from cost of sales and services + selling and administrative expenses. Market power is calculated using the Lerner index: (Total sales - Operating cost)/Total sales. Because the number of employed regular worker is not directly recorded before 2006, it is calculated by the number of total permanent employees minus the number of part-time workers. The number of non-regular workers is the sum of the numbers of part-time workers, temporary workers whose contract period is less than one month, and workers dispatched from temporary help agencies.

Table 2: Impact of Exchange-rate Fluctuation on Total Sales, 2001-2012

	%Δ of total sales$_{it}$			
	OLS	FE	IV	FEIV
Import share$_{it-1}\times$ %Δe_t	-0.017	-0.033	-0.067	-0.089
	(0.073)	(0.075)	(0.075)	(0.076)
Export share$_{it-1}\times$ %Δe_t	-0.826***	-0.835***	-0.904***	-0.935***
	(0.192)	(0.205)	(0.211)	(0.230)
Import share$_{it-1}$	-1.106***	-0.438	-1.150***	-0.455
	(0.361)	(0.667)	(0.365)	(0.669)
Export share$_{it-1}$	-0.476	-6.587***	-0.532	-6.499***
	(0.832)	(1.927)	(0.835)	(1.926)
Average market power$_i$	31.909***	–	31.895***	–
	(2.463)		(2.445)	
Industry-year fixed effects	Yes	Yes	Yes	Yes
Firm fixed effects	No	No	Yes	Yes
R^2	0.091	0.101	0.091	–
Observations	215,457	215,457	215,457	215,457

Standard errors are in parentheses.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Standard errors robust against firm-level clustering are reported in parentheses. The term $\ln e$ is the log of the Real Effective Exchange Rate (REER). In an IV regression, the log of the trend in the exchange rate, the cross term of the first difference of the log of the trend in the exchange rate and the one-period lag of the import share, and the cross term of first difference of the log of the trend in the exchange rate and the one-period lag of the export share are used as IV for the cross terms of the exchange rate and Import and Export share.

Table 3: Impact of the Exchange-rate Fluctuation on Regular and Non-regular Workers, 2001-2012

	%Δ of the number of regular workers$_{it}$		%Δ of the number of non-regular workers$_{it}$	
IV for exchange rate movement	NO	Trend component	NO	Trend component
Import share$_{it-1}$ × %Δe_t	-0.039	-0.059	0.086	0.030
	(0.040)	(0.047)	(0.131)	(0.148)
Export share$_{it-1}$ × %Δe_t	-0.161**	-0.173***	-0.854***	-0.754**
	(0.066)	(0.057)	(0.274)	(0.298)
Import share$_{it-1}$	-0.588**	-0.605**	-2.312***	-2.359***
	(0.298)	(0.304)	(0.822)	(0.820)
Export share$_{it-1}$	0.899*	0.891*	-5.107***	-5.034***
	(0.464)	(0.458)	(1.328)	(1.344)
Average market power$_i$	28.287***	28.284***	23.637***	23.633***
	(2.369)	(2.370)	(4.203)	(4.206)
Log(regular worker)$_{it-1}$	-0.406***	-0.406***	0.517***	0.517***
	(0.076)	(0.076)	(0.150)	(0.150)
Industry-year fixed effects	Yes	Yes	Yes	Yes
R^2	0.012	0.012	0.017	0.017
Observations	215,457	215,457	189,646	189,646

Standard are errors in parentheses.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Standard errors robust against firm-level clustering are reported in parentheses. The term $\ln e$ is the log of the Real Effective Exchange Rate (REER). For the first column, the two-year lag of log of regular worker is used as IV for the one-year lag of log of regular worker. For the second column, the log of the trend in the exchange rate, the cross term of the first difference of the log of the trend in the exchange rate and the one-period lag of import share, the cross term of the first difference of the log of the trend in the exchange rate and the one-period lag of export share, and two-year lag of log of regular worker are used as IV for the cross terms of the exchange rate and Import and Export share and one-year lag of log of regular worker.

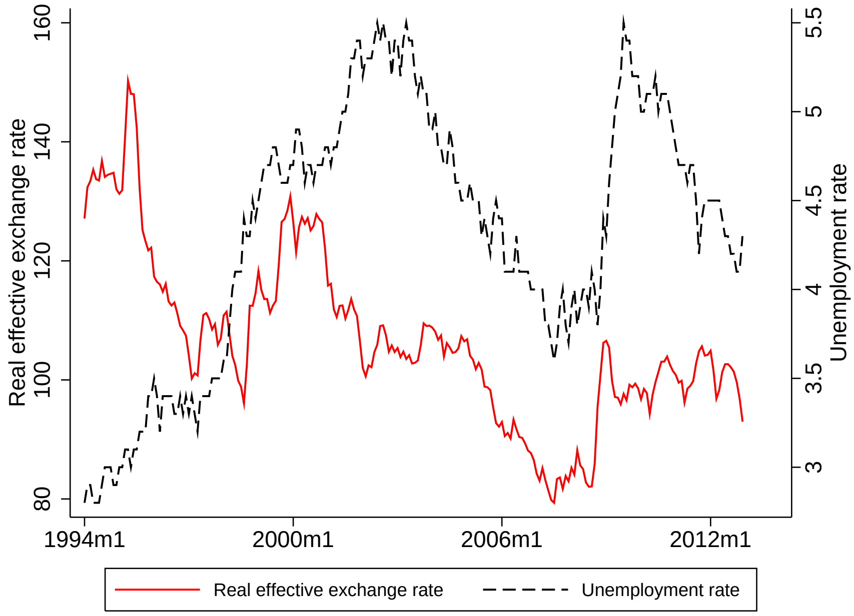

Figure 1: The real effective exchange rate and the unemployment rate

Source: The real effective exchange rate is from the Bank for International Settlements. The Unemployment rate is from the Labour Force Survey by the Ministry of Internal Affairs and Communication.

Note: Because of the Great East Japan Earthquake, the unemployment rate is calculated using Supplementary-estimated figures by the Ministry of Internal Affairs and Communication for some months.

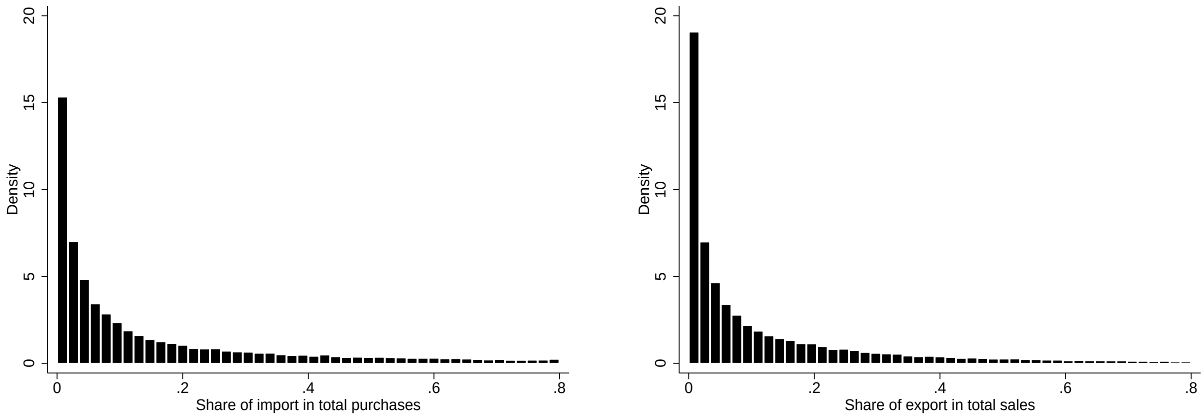

Figure 2: Distributions of Import Share and Export Share

The import share is calculated by dividing the purchase turnover (total value of overseas purchase) by the purchase turnover (total transaction value). The export share is calculated by dividing the sales amount (total value of direct exports) by another variable: the sales amount (total transaction value). The import share has a mean value of 0.043 and a standard error of 0.148. The export share has a mean value of 0.027 and a standard error of 0.099. The 22% of firm-year observations records positive export and 22% records positive import. The correlation between the import share and the export share is 0.234. The number of observations is 322,849. The graphs draw the distributions of import and export shares given positive numbers.

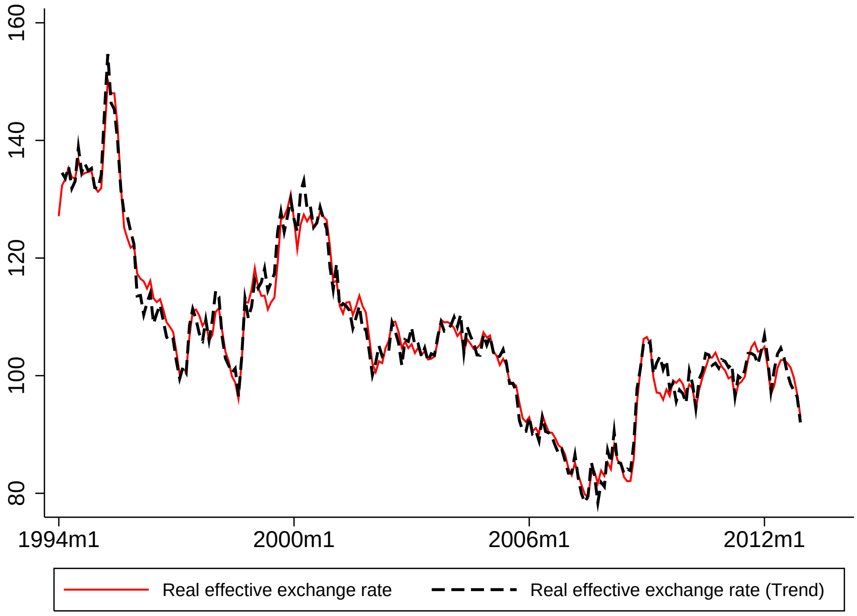

Figure 3: Real effective exchange

Source: Real effective exchange rate from the Bank for International Settlements. The trend series is obtained by applying the BN decomposition.