# Exchange Rate and Wage Adjustment: a Firm-Level Investigation*

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**Abstract**

In this paper we rely on a representative panel of manufacturing firms and estimate the implications for firm-level wages of changes in the permanent component of the exchange rate. Similarly to the response of employment and hours documented in Nucci and Pozzolo (2010), the direction and size of wage adjustment is shaped by the external orientation of each firm on both the sale and cost side of the balance sheet. Through the revenue side, wages are shown to rise after a currency depreciation and the effect is estimated to be larger the higher is the firm's exposure to sales from exports. On the contrary, a depreciation induces a cut in firm's wages through the expenditure side of the balance sheet and the effect is larger the higher is the incidence of imported inputs on total production costs. We show that, for a given degree of firm's external orientation, the sensitivity of wages to exchange rate swings is larger for firms with a lower market power. We also document that other transmission channels provide a degree of difference in shaping the effect of exchange rates on wages. These include: a) the degree of sectoral import penetration in the domestic market; b) the extent of inputs substitutability in firm's production; c) the percentage of newly hired workers in each firm in a given year and d) the composition of the firm's labor force by type.

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# 1 Introduction

A substantial body of empirical literature uncovers non-negligible effects of exchange rate movements on the real economy. Some contributions, for example, document that currency swings significantly affect firm's investment (Campa and Goldberg, 1999 and Nucci and Pozzolo, 2001) as well as employment and hours (Nucci and Pozzolo, 2010). As for these labor market effects, however, the latter finding contrasts with previous evidence by Campa and Goldberg (2001) on a weak employment response to exchange rates coupled with significant implications for real wages. Differently from Campa and Goldberg (hereafter, CG) and most other studies in this area of literature, Nucci and Pozzolo (hereafter, NP) use firm- rather than industry-level data and provide arguments for why the level of disaggregation of the data may affect the estimated impact on employment to a considerable extent. The present paper relies on the same microeconomic data and seeks to investigate how real wages at the firm level responds to exchange rate variations, thus complementing the NP (2010)'s analysis along a parallel dimension.

Assessing the consequences of exchange rate movements for the earnings of workers is indeed an open question. On the one hand, a group of contributions, focusing on aggregate data at the industry level, uncover a significant wage responsiveness to exchange rate oscillations. In particular, Revenga (1992) shows that changes in import prices induced by exchange rate swings do affect real wage in U.S. Manufacturing. Using data disaggregated by states and by industries, Goldberg and Tracy (2000) report statistically significant estimates of the earnings elasticities with respect to exchange rate, also providing evidence of a pattern of regional differences in their values. More recently, CG (2001) document a significant incidence of exchange rates on wages that varies across industries depending on their trade orientation and competitive structure.

On the other hand, however, a study on microeconomic data by Goldberg and Tracy (2003) finds that the overall wage effect of currency movements is in fact modest, although it can be sizeable for specific groups of workers. In their paper the authors focus on information on individual workers and analyze how the wage sensitivity to exchange rate is shaped by workers' specific characteristics such as those related to educational attainment and experience.[1]

[1] A notable feature of analyzing data on individual workers is that it allows to track the wage implications of a worker's job transition, which can be sizeable (see Kletzer, 1999). On this respect, Kletzer (1999) and Goldberg and Tracy (2003) show that increasing foreign competition as well as exchange rate changes account for a modest share of job displacement. On the other hand, however, job changing does affect the sensitivity of wages to exchange rate

Information on individual workers definitely provides a useful dimension for the analysis, as it allows to appraise which type of workers experience the largest wage adjustment (if any) after an exchange rate shock. We argue, however, that individual firm characteristics are of particular relevance in shaping the implications for wages of exchange rate fluctuations. In particular, because of the large heterogeneity across firms along several dimensions, even within narrowly defined industries, the firm-specific effects of exchange rate on wages can be to some extent washed out in the aggregation process. A very important dimension of such heterogeneity pertains to the international trade exposure of each individual firm and, indeed, a large body of literature emphasizes profound differences across firms in their degree of international orientation on both the export and imported inputs side (see Bernard et al, 2007). This calls for an investigation on data at the firm level. In particular, we are able to estimate a specific, time-varying responsiveness of the (average) wage to exchange rate for each individual firm and in doing so we allow for a number of transmission channels of the currency shock to the wages whose relevance varies from firm to firm.

In order to provide motivation for the empirical analysis, following NP (2001; 2010) and CG (1999; 2001) we rely on a theoretical model that pins down a number of mechanisms through which exchange rate changes influence the wages set by the firm. In particular, exchange rate is shown to affect the firm's profitability and thereby its equilibrium outcomes for wages and employment. Thus, in the aftermath of a currency depreciation, for example, there is a positive wage and employment adjustment through the revenue side of the income account, whose size increases with the extent of firm's exposure to foreign product markets. Through the cost side, conversely, a depreciation tends to reduce wages (and employment) in the firm and the effect is stronger the more a firm relies on imported intermediate inputs for its production. Another prediction of the theoretical model, which is testable with our data, is that, for a given level of firm's external orientation, the degree of wage sensitivity to exchange rate is influenced by the market power of the firm. In particular, the impact on wages is found to be more pronounced the lower is the firm's pricing power in its destination markets (see CG, 2001). We also investigate the empirical relevance of other features in shaping the responsiveness of wages to exchange rate at the firm level. A relevant aspect deals with the degree of competitive pressure exerted by foreign producers in the firm's domestic market. In line with NP (2010), we therefore investigate on our firm data whether differences across industries in the degree of import penetration are conducive to diverging patterns of the responses of wage to currency shocks. In doing so, we combine firm-level information on the exposure of the firm's sales on the domestic product markets with data on import penetration in the industry to which the firm belongs. We find that a currency appreciation, for example, by reducing firm's competitiveness in

through the impact of currency swings on the size of the wage adjustment after a job transition (Goldberg and Tracy, 2003).

the domestic market, reduces profitability and thereby the equilibrium wages through the domestic revenue channel and this effect is found to be stronger the higher is the extent of import penetration on the one side and the larger is the degree of firm's orientation to the domestic product markets on the other. We also investigate another possible source of specificity in the wage sensitivity to exchange rate by examining whether the wage responsiveness through the cost side varies across firms in light of differences in their degree of substitutability in production between imported and domestically produced intermediate inputs.

Moreover, in shaping the impact of exchange rate movements on the wages set by the firm a relevant aspect deals with the share of newly hired workers in the firm in a given year. In particular, we consider the hiring rate for each firm and ask ourselves whether two firms with a different percentage of newly hired employees in a given year but which are otherwise identical along all dimensions (e.g. international exposure) exhibit a different sensitivity of the (average) wage to exchange rate shocks. We find that this sensitivity is indeed of a larger size for the firm with the higher hiring rate, as we estimate for it a stronger wage responsiveness to a currency shock along both the two transmission channels related to the firm's foreign exposure (the one though exports and the one through imported inputs). Arguably, this result seems to complement the one obtained on employees data by Goldberg and Tracy (2003), who detect a significant effect of exchange rate on the amount of the worker's wage adjustment associated with a transition from a job to another.

Finally, whilst our data do not allow to control for individual worker characteristics such as the skill level, we do have, however, time-varying information for each firm on the composition of its workforce by type. We therefore examine whether the overall exchange rate elasticity of wages tends to vary in coincidence with a different incidence in the firm of the blue-collar employees (vis-a-vis the white-collars).

We organize the remainder of the paper as follows: section 2 presents the theoretical relationships that guide our empirical analysis and provide motivation for it. Section 3 describes the data, the empirical specification and the estimation methodology. In section 4 we report the baseline empirical results and in section 5 we investigate additional features that provide further characterizations of the wage responsiveness to exchange rate swings. Finally, section 6 concludes.

## 2 Theoretical framework

### 2.1 The Model

In this section we present a simple model of the labor market that allows us to illustrate the mechanisms through which exchange rate swings induce equilibrium wage adjustment. Following CG (1999; 2001) and NP (2001; 2010), we consider the optimal conditions for profit maximization of a firm operating in an imperfectly competitive market. The firm's problem is defined as:

$$\pi(e) = \max_{q,q^*,z,z^*,L} p(q,e)q + \frac{p^*(q^*,e)q^*}{e} - zs - \frac{z^*s^*(e)}{e} - w^N L, \tag{1}$$

subject to the technology constraint:

$$q + q^* = Q = F(L, z, z^*).$$

where $q$ and $q^*$ are the volumes of production in the domestic and in the foreign markets, respectively, and the inverse demand functions, $p(q,e)$ and $p^*(q^*,e)$ have been inserted in the profit function. $L$ is employment and $z$ and $z^*$ are the levels of domestically produced and imported non-labor inputs, respectively; $w^N$ is the nominal wage and $s$ and $s^*$ are the prices of the domestically produced and the imported inputs, respectively, expressed in local currency; $e$ is the exchange rate, quoted as the number of foreign currency units per domestic currency unit (i.e., an increase of $e$ is therefore a currency appreciation). The first order conditions with respect to $q$ and $q^*$ for the solution of the constrained maximization problem (1) are:

$$\frac{\partial p(q,e)}{\partial q} q + p - \lambda = 0, \tag{2}$$

$$\frac{\partial p^*(q^*,e)}{\partial q^*}\frac{q^*}{e} + \frac{p^*}{e} - \lambda = 0. \tag{3}$$

where $\lambda$ is the Lagrange multiplier for the technology constraint. By defining $\eta$ and $\eta^*$ as the price elasticities of demand in, respectively, the domestic and the foreign product market, from equations (2) and (3) we obtain the following relationship, linking prices and demand elasticities in the home and foreign markets:

$$\lambda = p(1 + \frac{1}{\eta}) = \frac{p^*}{e}(1 + \frac{1}{\eta^*}). \tag{4}$$

Similarly, the optimal conditions with respect to $z$, $z^*$ and $L$ are:

$$-s + \lambda \frac{\partial F(L,z,z^*)}{\partial z} = 0, \tag{5}$$

$$-\frac{s^*(e)}{e} + \lambda \frac{\partial F(L,z,z^*)}{\partial z^*} = 0, \tag{6}$$

$$-w^N + \lambda \frac{\partial F(L,z,z^*)}{\partial L} = 0. \tag{7}$$

By combining Eq. (4) with the above three equations, the following equilibrium conditions are derived, equating the marginal revenue product of each input to its marginal cost (see NP, 2011; 2010):

$$\frac{\partial F(L,z,z^*)}{\partial z} = \frac{s}{p(1+\frac{1}{\eta})}, \tag{8}$$

$$\frac{\partial F(L,z,z^*)}{\partial z^*} = \frac{s^*(e)}{p^*(1+\frac{1}{\eta^*})}, \tag{9}$$

$$\frac{\partial F(L,z,z^*)}{\partial L} = \frac{w^N}{p(1+\frac{1}{\eta})}. \tag{10}$$

If we assume that technology, $F(\cdot)$, is described by a constant return to scale production function, we apply Euler's theorem and express total output as follows:

$$Q = F(L,z,z^*) = \frac{\partial F(L,z,z^*)}{\partial L}L + \frac{\partial F(L,z,z^*)}{\partial z}z + \frac{\partial F(L,z,z^*)}{\partial z^*}z^*. \tag{11}$$

By defining $\frac{1}{\mu} = (1+\frac{1}{\eta})$ and $\frac{1}{\mu^*} = (1+\frac{1}{\eta^*})$ as the reciprocals of the mark-up ratios set, respectively, in the domestic and foreign product markets, and substituting Eqs. (8) through (10) into Eq. (11), simple algebraic manipulations yield the following equilibrium condition (see CG, 2001 and NP, 2010):

$$w^N L = \frac{pq}{\mu} + \frac{p^*q^*}{e\mu^*} - (sz + \frac{s^*z^*}{e}). \tag{12}$$

The above expression characterizes firm's optimal labor demand in the absence of adjustment costs. By applying the logarithmic transformation to it and denoting $\widetilde{L}$ as the optimal demand in the absence of adjustment costs yield

$$\ln w^N = \ln[\frac{pq}{\mu} + \frac{p^*q^*}{e\mu^*} - (sz + \frac{s^*z^*}{e})] - \ln \widetilde{L}. \tag{13}$$

Let us allow for adjustment costs in hiring and firing workers and postulate the following partial adjustment equation for labor demand

$$\ln L_t = \varphi \ln L_{t-1} + (1-\varphi)\ln \widetilde{L}_t; \tag{14}$$

it dictates that optimal labor demand in period $t$ depends on the previous period's level, $t-1$, and on the optimal current level in the absence of adjustment costs, $ln\widetilde{L}_t$. $\varphi$ is a parameters governing the speed of adjustment (see NP, 2010).

Combining Eqs. (13) and (14) and using the time subscripts yield the following expression

$$\ln w_t^N = \ln[\frac{p_t q_t}{\mu_t} + \frac{p_t^* q_t^*}{e_t \mu_t^*} - (s_t z_t + \frac{s_t^* z_t^*}{e_t})] - \frac{1}{1-\varphi}(\ln L_t - \varphi \ln L_{t-1}). \tag{15}$$

In order to fully characterize the labor market, we need to introduce a labor supply schedule. Following CG (2001) and NP (2010), we assume that labor supply obeys the following relationship:

$$\ln L_t = a_0 + a_1 \ln w_t + a_2 \ln Y_t \tag{16}$$

where $Y$ is a measure of aggregate demand and $w$ is the real wage, i.e. the nominal wage, $w_t^N$ deflated by an aggregate price index, $\overline{P}$. By equating labor demand (Eq. 15) and labor supply (Eq. 16), simple manipulations yield

$$\ln w_t = A(1-\varphi)\{\ln[\frac{p(q_t, e_t) \cdot q_t}{\mu} + \frac{p^*(q_t^*, e_t) \cdot q_t^*}{e_t \mu^*} - (s_t z_t + \frac{s^*(e_t) z_t^*}{e_t})] - \ln \overline{P}_t\} + A\varphi \ln L_{t-1} - A(a_0 + a_2 \ln Y_t), \tag{17}$$

where $A = \frac{1}{1-\varphi+a_1}$. After differentiating the above equation with respect to the exchange rate, simple algebraic transformations yield the following expression for the elasticity of real wages, $w$, with respect to exchange rate, $e$

$$\frac{d \ln w_t}{d \ln e_t} = \frac{1}{\overline{\mu}} \beta[-\chi(1 - \eta_{p^*,e}) + (1-\chi)\eta_{p,e} + \alpha(1 - \eta_{s^*,e})]A(1-\varphi), \tag{18}$$

where $\chi \in [0,1]$ is the share of sales in foreign markets over total sales and $(1-\chi) \in [0,1]$ is the share of sales in domestic market over total sales; $\alpha \in [0,1]$ is the share of production costs on imported inputs in total costs; $\eta_{p,e} \in [-1,0]$ and $\eta_{p^*,e} \in [0,1]$ are the elasticities of, respectively, domestic and foreign prices with respect to the exchange rate (i.e., the pass-through elasticities); $\eta_{s^*,e} \in [0,1]$ is the elasticity of foreign input prices with respect to the exchange rate. $\beta$ is the share of labor costs over total revenues. In deriving the above expression we have assumed for simplicity that there is no distinction between the mark-up set in the domestic market, $\mu$, and the one in the foreign product markets, $\mu^*$. In both cases we have used $\overline{\mu}$, which can be interpreted as the average value of the destination-specific mark-up ratios (see NP, 2010). Moreover, in obtaining Eq. (18) we have used the fact that, under constant returns to scale, total revenues can be expressed as the product of production costs (the wage bill plus intermediate input expenditure) and the mark-up ratio, $\overline{\mu}$.

Eq. (18) represents a useful theoretical background for our empirical analysis, providing a variety of testable implications. The following section discusses in more detail the number of channels, explicitly identified in our theoretical model, through which exchange rate movements affect the equilibrium outcome for wages.

### 2.2 The Channels of Transmission of Currency Swings to Wages

Equation (18) predicts that exchange rate swings affect wage adjustments. In particular, if we focus on the revenue side of the firm's balance sheet a currency depreciation (a reduction of $e_t$) has a positive effect on the firm's marginal revenue product of labor and thereby on the equilibrium outcome for real wages, as is shown by the sum of the first two terms inside brackets in Eq. (18), $-\chi(1-\eta_{p^*,e})+(1-\chi)\eta_{p,e}$, which is non-positive. In particular, a depreciation is predicted to exert a positive effect on wages along both the foreign and domestic sales channels. By contrast, a currency depreciation negatively affects, through the cost side of the balance sheet, the marginal revenue product of labor and thereby real wages. Indeed, the term $\alpha(1-\eta_{s^*,e})$ inside brackets in Eq. (18) is non-negative. Very importantly, the extent of these adjustments depends on the external orientation of the firm towards international product markets. On the export side, the positive effect on wages of an exchange rate depreciation is larger the higher is the share of foreign sales on total sales, $\chi$, i.e. the more a firm is exposed to foreign markets through the export of its products. On the revenue side as a whole, i.e. including both domestic and foreign sales, the positive effect on wages on a currency depreciation is also amplified as the export share of sales, $\chi$, becomes larger, but this prediction holds true only if the following condition is met: $|\eta_{p,e}|+\eta_{p^*,e}<1$, i.e. if the sum of the exchange rate pass-through elasticities (their absolute value) is less than one (NP, 2010). On the expenditure side, conversely, the size of the negative effect on wages of a currency depreciation depends on the extent of firm's reliance upon imported inputs. This type of exposure is captured in Eq. (18) by $\alpha$, the share of expenditure on imported inputs on total costs: the larger is this share, the more pronounced the negative implications for wages of a depreciation through this channel of exposure (see CG, 1999; 2001 and NP 2001; 2010).

The theoretical framework illustrated in the previous section highlights other important features that shape the response of wage to exchange rate swings. First, the firm's degree of market power, as measured by the firm's mark-up ratio, $\overline{\mu}$, does enters Eq. (18) and the prediction is that, everything else being identical for two firms (e.g., type of international exposure and pass-through elasticities), the one with a lower degree of monopoly power tends to exhibit a more sizeable (absolute value of the) elasticity of wages to exchange rate. Indeed, firms with a lower market power tend to be less capable to absorb currency shocks so that the impact on wages is relatively more pronounced.

To see this, recall that an exchange rate depreciation (e.g. a decrease of $e$) drives down the export price in the foreign currency by an amount that depends on the pass-through elasticity, $\eta_{p^*,e}$. This price decline therefore yields an increase of foreign demand, $q^*$, and thereby of profitability and wages, which is larger the higher is the price elasticity of foreign demand, $\eta^*$. Given the negative relationship between the firm's mark-up ratio and the price elasticity of demand, the sensitivity of wage to currency swings is indeed magnified when the firm's market power is relatively low.

Moreover, another prediction of the model (again see Eq. 18) is that the exchange rate pass-through elasticities contribute to shape the adjustment of wage in response to currency shocks. The exchange rate elasticity of prices set by the firm in the destination market's currency, $\eta_{p^*,e}$ ranges from zero (no pass-through) to one (complete pass-through). From Eq. (18) we note that, for a given level of external orientation on the export side, $\chi$, the smaller is the elasticity of exchange rate pass-through to foreign prices, $\eta_{p^*,e}$, the larger is the (absolute value of the) wage response to a shift in $e_t$. Importantly, a number of contributions show that this exchange rate pass-through elasticity does depend on market structure and in particular on the extent to which firms' products are differentiated and the substitution among different variants is large (Yang, 1997). These studies include Dornbusch (1987) and Knetter (1993) and show that the pass-through tends to be low if the degree of competition in the foreign markets is high. Therefore, in the limiting case of a perfectly competitive foreign destination market, the firm is a price taker and the pass-through elasticity would be zero. Thus, the prediction through this channel contributes to reinforce the previous conclusion that the lower is the firm's pricing power the higher is the exchange rate sensitivity of wages.

If we focus on firm's competition in the domestic market, we have established that a currency depreciation, by making foreign products more expensive, rises the competitiveness of domestic firms in the home market, thus increasing their sales and thereby their profitability and wages. Eq. (18) predicts that the exchange rate pass-through elasticity of firm's prices in the domestic market, $\eta_{p,e}$, plays an important role in shaping this effect. The values of this domestic pass-through elasticity range from minus one (complete pass-through) to zero (no pass-through), and again it depends on market structure. Specifically, the elasticity is (in absolute value) a decreasing function of the firm's monopoly power in the home market. In the limiting case of a perfectly competitive domestic destination market, where the domestic firm is a price taker, a currency appreciation must be rebated by a one-to-one firm's own price cut (a pass-through elasticity equal to minus one). Thus, a currency appreciation induces a reduction in the value of domestic sales, profitability and wages and the lower the firm's market power the larger this decline turns to be. The intuition is that the higher the competitive pressure exerted by foreign producers, the more responsive domestic sales, profitability and wages are in the aftermath of a currency shift. Indeed the domestic pass-through elasticity reflects the degree of this competitive pressure from foreign producers and is often assumed to be proportional to the degree of import penetration in the domestic market (see e.g. Dornsbusch, 1987 and CG, 2001).

Market structure also affects the effects through the expenditure side of the balance sheet. Indeed, the increase of wages after an exchange rate appreciation taking place through a reduction in the expenditure for imported inputs depends on the extent of competition in the market for intermediate inputs. Indeed, Eq. (18) establishes that the effect of exchange rate on wage adjustment is larger the smaller the pass-through elasticity of foreign input prices to the exchange rate, $\eta_{s^*,e}$. The latter ranges from zero (no pass-through) to one (complete pass-through).

The theoretical framework allows us to uncover a number of testable implications on the channels of transmission of exchange rate swings to wage adjustments. These theoretical predictions are summarized by Eq. (18) and lend themselves to the empirical scrutiny to which we now turn. In doing so, we first present the firm-level panel data that we use.

# 3 The Data and Regression Specification

## 3.1 The Data

In the empirical investigation the microeconomic data that are used are the the same as those of NP (2010). They are drawn from two different statistical sources. The first one is the Bank of Italy's Survey of Investment in Italian Manufacturing (SIM) carried out at the beginning of every year since 1984 on a representative sample of over 1,000 firms stratified by industry, firm size and location. The data are of extremely high quality also for the professional expertise of the interviewers, who are officials of the Bank of Italy establishing long-term relationships with the firms' managers. In order to ensure the quality standard of data, only medium-large firms, defined as those with more than 50 employees, are included in the Survey. We used SIM to gather firm-level information on total revenues and revenues from exporting, employment and hours worked.

The second data source of firm-level data is the Company Accounts Data Service reports, a database maintained by a consortium of the Bank of Italy and a pool of banks, collecting information from balance sheets and income statements of a sample of about 40,000 Italian firms. The detailed information from the annual accounts are reclassified to ensure comparability across firms. This database provides us with firm level information on labor compensation, intermediate input expenditure, value added and gross output. Data from the two sources are merged to construct an unbalanced panel of slightly fewer than 2,400 firms. As in NP (2010), the data used for estimation covers the period 1984-1998, the one antecedent to the introduction of the Euro. This period was characterized by pronounced swings of the Italian currency coupled with a high degree of international exposure of Italian firms.

We compute wages at the firm-level by considering both firm's labor costs per employee and firm's labor costs per hour. These measures of labor compensation are expressed in real terms by using the GDP deflator. The number of firm's employees is the average value within each year. The empirical counterpart of the two key variables on the firm's international exposure, $\chi$ and $\alpha$, are calculated at the firm level for each year as follows: $\chi_{it}$ is the export share of sales of firm $i$ in year $t$ computed using data from SIM. In order to derive $\alpha_{it}$, the share of imported inputs in total input purchases of firm $i$ in year $t$, we had to augment firm-level information from the two statistical sources with additional information as the value of firm's expenditure on imported inputs is not available. As documented in NP (2001 and 2010), we do so by relying on the 44-industry input-output table of 1992 for the Italian economy. in particular, we extract for each industry $j$ the values of both imported intermediate inputs and total intermediate inputs (domestically produced and imported). Then, by using time series on import demand and production for each industry, we updated backward and forward the values of input purchases from the input-output table that refer to one year only. Lastly, we computed the share of costs on imported inputs in total input purchases as $\alpha_{it} = \frac{\left(\frac{IM_{jt}}{TE_{jt}}\right)TE_{it}}{TE_{it}+LC_{it}}$, where $IM_{jt}$ is the value of intermediate inputs imported by industry $j$ (the industry to which firm $i$ belongs), $TE_{it}$ and $TE_{jt}$ are the values of total expenditure for intermediate inputs of, respectively, firm $i$ and industry $j$, and $LC_{it}$ is labor costs of firm $i$.

In order to provide a time-varying measure of firm's market power we follow the approach developed by Domowitz et al. (1986) and compute a firm's index of mark-up as the ratio of the firm's value added net of labor compensation to the value of firm's total production. Ideally, we would use distinct destination-specific mark-up ratios, for example in the home and the foreign markets. Since our data do not allow to derive them we construct, for each year, a firm's average measure of market power.

For measuring exchange rate, we separately use both the export and import real effective exchange rates of the Italian lira constructed by considering 24 different bilateral exchange rates. Both real exchange rates are computed using producer price indexes (see Banca d'Italia, 1998). In the empirical analysis, we use the permanent component of exchange rate variations which has been derived by applying the Beveridge and Nelson (1981) procedure that decomposes a non-stationary series into its permanent and transitory components (see NP, 2010 for details). Figure 1 shows the time profile of the monthly data on import and export real exchange rates in the period analyzed with an increase of the exchange rates amounting to a real appreciation. While they exhibit a very similar pattern, some differences emerge in the mid-eighties and at the beginning of the nineties.

### 3.2 The Econometric Specification

In assessing on empirical grounds the wage response to exchange rate fluctuations we rely on a baseline equation which has the following specification

$$\Delta w_{it} = \beta_0 + \beta_1 \chi_{it-1} \Delta peer_t + \beta_2 \alpha_{it-1} \Delta pmer_t + \beta_3 \chi_{it-1} + \beta_4 \alpha_{it-1} + \\ + \beta_5 \Delta s_{it-1} + \beta_6 MKUP_{it-1} + \beta_7 \Delta l_{it-1} + b' Z_{it} + \lambda_i + u_{it}, \quad (19)$$

where lower-case letters denote the logarithmic transformation of the variable; $W_{it}$ is the average labor compensation in real terms paid by firm $i$ at time $t$ and we alternatively use the real labor compensation per employees and the one per hour. $S_{it}$ is the value of real sales and $PEER_t$ and $PMER_t$ are the permanent components of, respectively, export and import real effective exchange rates, defined so that an increase in the exchange rate is an appreciation. $MKUP_{it}$ is an index of firms' market power. $L_{it}$ is the amount of labor input and we alternatively measure it as the number of employees and the number of total hours. $Z_{it}$ is a vector of dummy variables controlling for the different years, industries, sizes and geographic locations in which each firm operates. The empirical specification is in first-differences in light of the non-stationarity of the exchange rate time series.

While the dynamic Eq. (19) is a reduced form, it can be seen as the empirical counterpart of Eq. (18) and allows us to test a number of theoretical implications of the model. The key variables for characterizing the wage adjustment in response to currency swings are 1) $\chi_{it-1} \cdot \Delta peer_t$, the interaction term of the export share of sales lagged by one period with the export exchange rate variation; and 2) $\alpha_{it-1} \cdot \Delta pmer_t$, the interaction term of the lagged share of expenditure for imported inputs in total purchases with the import exchange rate variation. The advantage of this approach is that the estimated sensitivity of wages to currency movements varies across firms and over time depending on the evolving external orientation of each specific firm on both the revenue and cost side (see CG, 2001 and NP, 2010). In other words, the empirical framework (19) allows us to derive a time-varying firm specific estimated response of firms' labor compensation to exchange rate oscillations. Of course, the export share of sales and the share of imported inputs are also inserted in the specification as single regressors in isolation.

The specification includes the lagged value of change in employment (or hours) in order to control for the adjustment lags that typically characterizes the labor market. In order to control for demand conditions, we include in the equation the lagged value of changes in the firms' real sales; we also include the lagged value of the mark-up ratio to control for the effect of marginal profitability on wages that is independent of exchange rate developments. The dummy variables included in the equation comprise the year dummies that capture the time-varying effects on wages common to all firms. The specification also includes fixed effects, $\lambda_i$, controlling for individual firm latent heterogeneity; $u_{it}$ are the disturbance terms for which we assume that $E(u_{it}) = E(u_{it}u_{is}) = 0$, for all $t \neq s$.

As in NP (2001 and 2010), the methodology used for estimation is the generalized method of moments (GMM) estimator for dynamic panel data model, which was shown to be efficient within the class of instrumental variable estimators (Arellano and Bond, 1991). Indeed, since in Eq. (19) the lagged values of the mark-up ratio and of change in employment (hours) and sales are likely to be correlated with the firm-specific fixed effects, $\lambda_i$, this endogeneity of regressors would cause inconsistency of the parameters estimated with standard panel methods while the GMM estimator would ensures their consistency. Specifically, following Arellano and Bover (1995) and Blundell and Bond (2000), we rely on the system GMM panel estimator which augments the Arellano and Bond (1991) estimator by building a system of two equations: the original equation and a transformed one. As in Arellano and Bond (1991), in the transformed equation a variety of instruments in levels can be used. However, under the novel approach a further assumption is made: that first differencing the instrumenting variables in the original equation makes them uncorrelated with fixed effects. This allows us to exploit an even larger number of orthogonality conditions than before, by resorting to a larger instrument set. In the estimation we utilize as GMM-type of instruments the lagged values of real sales, employment (or hours) and of the mark-up dated period $t$-2 and earlier. The validity of our specification is ascertained by conducting: a) the Hansen test of over-identifying restrictions, which seeks to verify the orthogonality between instrumental variables and the disturbance terms and b) the Arellano-Bond test for second-order serial correlation of residuals of the transformed equation. We now turn to present and discuss the estimation results.

# 4 Empirical Results

## 4.1 The Baseline Specification

The results from estimating Eq. (19) are presented in table 1. The effect of exchange rate fluctuations on labor compensation set by the firms is statistically significant and this holds true by considering both the compensation per employee (column 1) and the compensation per hour (column 2). The estimated coefficients on the two interaction terms, capturing the effect of currency swings on wages through, respectively, the foreign sale and the imported intermediate inputs channels have the expected sign and are statistically significant. For example, if we focus on the response of real wages per employee (see column 1) the estimated coefficient of $\chi_{it-1} \cdot \Delta peer_t$ is $-0.722$ with a standard error of 0.140 while the estimated coefficient of $\alpha_{it-1} \cdot \Delta pmer_t$ is 2.608 with a standard error of 0.753. These results support the theoretical prediction that a currency depreciation, i.e. a negative variation over time of both $peer_t$ and $pmer_t$ is conducive to a wage rise in real terms through the foreign sales side of the balance sheet and to a wage decline through the expenditure side. Both effects are estimated to be stronger the higher the firm's international exposure through exports, i.e. the higher is $\chi_{it-1}$, and the higher the firm's reliance on imported inputs, i.e. the higher is $\alpha_{it-1}$.

Naturally the question arises as to whether an exchange rate appreciation leads to a rise or fall of labor compensation set be firms. As we argued in NP (2010), our empirical framework is not the most suitable one for ascertaining the aggregate effect of exchange rate swings on wages. On the contrary, we believe that the primary advantage of our approach is that it allows us to capture the firm-specific relevance of each transmission channel. This implies that a firm-specific, rather than aggregate, wage response to exchange rates can be estimated on our microeconomic data for each period. To do so, let us consider first the mean value of both the export share of sales, $\chi_{it}$, and the share of imported input costs, $\alpha_{it}$: these mean values are, respectively, 0.298 and 0.139. If we evaluate the shares reflecting external orientation at these mean values, and use estimation results in table 1, column 2, the estimated elasticity of wage per hour to exchange rate change is $-0.134$. This means that the effect of a one per cent currency depreciation on the hourly wage for a hypothetical firm with this type of foreign exposure is a 0.13 per cent real wage expansion. Furthermore, instead of considering a hypothetical firm exhibiting average shares, let us consider firms' heterogeneity in terms of external orientation, by focusing on the difference between import and export shares, $\alpha - \chi$ and in particular on the firms at the 25th, median and 75th percentile of the distribution of this difference. For the firm at the 25th percentile (with $\alpha = 0.09$ and $\chi = 0.44$), based on the results documented in table 1 column 2, a one per cent currency depreciation determines a 0.27

per cent rise of real wages per hour. For the median firm (with $\alpha = 0.12$ and $\chi = 0.22$), hourly wages rises by 0.09 per cent. For the firm at the 75th percentile (with $\alpha = 0.08$ and $\chi = 0.01$), hourly wages would drop by 0.05 per cent after a one per cent (export and import) exchange rate depreciation.

The estimation results also document that firm's profit margins as measured by the mark-up ratio, $MKUP_{it-1}$ exerts a positive effects on wages and so does the lagged change in employment (or hours), $\Delta l_{it-1}$. The change in total sales, included in the specification as a control variable, does not have a statistically significant effect on wage per employee while the effect on wage per hour is negative and significant. As discussed before, the specification includes a number of control variables. These are dummy variables that refer to the year, the firm's industry, the size and the firm's geographic location. We report the value of the Wald tests for the joint significance of each group of these dummies and the results indicate that these effects are statistically significant. Evidence on the validity of our baseline specification in both columns 1 and 2 is provided by the values of the Hansen statistic for over-identifying restrictions and of the test for absence of second-order serial correlation of residuals.

### 4.2 The Role of Market Power

A notable implication of the theoretical model is that, for a given international exposure of firms, the sensitivity of wages to exchange rate fluctuations is magnified when the degree of firm's market power in product markets is low. We address this issue on empirical grounds and estimate our baseline specification on two different sub-samples (see CG, 2001 and NP, 2010). These sub-samples are obtained using the median value of firms' mark-ups as a threshold criterion for splitting the sample. The estimation results are reported in table 2: the effect of exchange rate swings on (average) labor compensation both per employee and per hour is stronger for firms with a lower mark-up ratio. If we focus, for example, on the impact on compensations per hour, the estimated effect through the cost side is 3.751 with a standard error of 1.204 for the firms with relatively low pricing power, which is indeed larger compared to the corresponding one for firms with higher pricing power (in this case it is 0.528 with a standard error of 0.318; see columns 3 and 4 of table 2). By the same token, the estimated impact of exchange rate through the revenue side is $-1.182$ with a standard error of 0.229 in the case of firms with lower market power, while it is $-0.302$ (with a standard error of 0.137) for firms exhibiting higher pricing power in the product markets.

To analyze this issue in more detail, following NP (2010) we also modify the baseline specification. In particular, we replace the two key explanatory variables in our regression, namely the interaction terms between exchange rate variations and the variables of firm's international exposure (respectively, $\chi_{it-1} \cdot \Delta peer_t$ and $\alpha_{it-1} \cdot \Delta pmer_t$) with two new interaction terms that, in addition to the original variables, comprise also the firm's level of market power, i.e. $MKUP_{it-1}$, as a further multiplicative term. The new regressors are therefore the following: 1) $\chi_{it-1} \cdot \Delta peer_t \cdot (1 - MKUP_{it-1})$ and 2) $\alpha_{it-1} \cdot \Delta pmer_t \cdot (1 - MKUP_{it-1})$.

The theoretical model predicts that say a depreciation (i.e. a negative value of $\Delta peer_t$) would increase wages through the revenue side and the impact is expected to be stronger the higher is the share of exports from sale and the lower is the price mark-up. Therefore, a negative estimate of the parameter for the interaction term for the revenue side would lend empirical support to this prediction. Indeed, table 3 shows that the estimated coefficient is $-1.100$ (with a standard error of 0.184) when we consider labor compensation per employee and $-0.513$ (with a standard error of 0.163) when we consider labor compensation per hour. On the other hand, we expect a depreciation to reduce wages through the cost side with the size of the impact being higher (in absolute value) the higher is the share of expenditure on imported input over total costs and the lower is the price mark-up. Estimating a positive parameter for the interaction term on the cost side would support the model's prediction and this is the result we obtain. Indeed, the estimated coefficient is positive and statistically significant when we consider both labor compensation per employee (2.461 with a standard error of 0.848; see table 3, column 1) and labor compensation per hour (0.706 with a standard error of 0.342; see table 3, column 2) .

# 5 Additional Effects on the Wage Sensitivity to Exchange Rates

## 5.1 Import Penetration and Substitutability between Inputs

In order to provide further characterizations of the linkage between exchange rate and wages we analyze other features that may contribute to shape the sensitivity of firm level wages to currency shocks.

So far we have emphasized foreign exposure of a firm as captured by both the extent of the exporting activity and the incidence of imported intermediate inputs. However, the firm is exposed to international competition also in the domestic product markets and the degree to which this happens depends on two features: 1) the extent of import penetration in the domestic industry to which a firm belongs and 2) the share of firm's sales in the domestic market over total sales. As we discussed in section 2, the more relevant are the import penetration and the firm's exposure to domestic revenues, the more severe is the competitive pressure exerted by foreign producers in the firm's domestic market. This channel may introduce another degree of difference across firms in the estimated impact of exchange rate movements on labor compensations. Following NP (2010), we consider the following specification

$$\Delta w_{it} = \beta_0 + \beta_1 \chi_{it-1} \Delta peer_t + \beta_2 \alpha_{it-1} \Delta pmer_t + \beta_3 \chi_{it-1} + \beta_4 \alpha_{it-1} +$$
$$+ \beta_5 \Delta s_{it-1} + \beta_6 MKUP_{it-1} + \beta_7 \Delta l_{it-1} + \sum_{j=1}^{K} [\gamma_j (1 - \chi_{it-1}) IP_{jt-1} \Delta peer_t D_j] + b' Z_{it} + \lambda_i + u_{it}, \tag{20}$$

which is identical to Eq. (19) except for the inclusion of the summation term. The latter is made by: a) $D_j$, which is a dummy variable for each industry $j$ (with $j = 1, 2, ...K$) and is equal to one if firm $i$ belongs to industry $j$ and zero otherwise; b) $IP_{jt-1}$, the (lagged value of the) industry $j$'s import penetration ratio, as measured by the share of imports of products $j$ over domestic demand for those products. The latter is obtained as the industry's sales plus the imports of products of industry $j$ minus the industry's exports; c) $(1 - \chi_{it-1})$, is domestic sales over total sales and reflects the degree of firm's exposure on the domestic market. All these variables interact with the export exchange rate change and for each industry we estimate the industry-specific coefficients, $\gamma_j$, associated with the corresponding interaction. These coefficients are expected to be negative because, say, a currency appreciation (a rise of $peer_t$) lower the firm's competitiveness in the domestic market thus reducing its profitability through the domestic revenue side and thereby the equilibrium wages. The size of this effect would vary across firms depending on the relevance of domestic sales on total sales and on the extent of import penetration. To ascertain this, we estimate Eq. 20 and the results are reported in table 4. The estimated coefficients of the two key interaction terms have the expected sign and are statistically significant. In analyzing the industry-specific values of the estimated coefficients $\gamma_j$, capturing the effect of exchange rate on wages through import penetration, we first test whether they are different among each others. To do so, we conduct a Wald test and indeed the null hypothesis of identical industry-specific coefficients is strongly rejected (with a p-value of 0.00). In table 5 we report the values for each industry of the estimated wage sensitivity to exchange rate through the import penetration channel. To compute them for each industry $j$, we combine the value of the coefficient $\gamma_j$ with: a) the corresponding industry-specific average value across firms and over time of $(1 - \chi_{it-1})$ and b) the time average of $IP_{jt}$ for the industry. In the large majority of industries (12 out of 15) the estimated wage elasticity to exchange rate through the import penetration channel has the expected negative sign. Moreover, for each industry-specific estimated value of the elasticity, we also report the associated rank. In order to gauge whether these estimates are sensible, in table 5 we compare these estimates of the elasticities with the corresponding values of import penetration for each industry reported in the table with the associated rank. As found in NP (2010) for the employment elasticity, it turns out that the estimated impact of exchange rate on wages through the domestic sales side is larger for industries exhibiting a higher degree of import penetration. The strongest effects are recorded for Electrical Machinery and for Computers and Office equipments. For the latter industry, the extent of import penetration is very high (58 per cent; ranked n. 1) and for Electrical Machinery it is also sizeable (29 per cent; ranked n. 4). We have also computed the Spearman's rank correlation between a) the (absolute values of the) estimated industry-specific wage responses on the domestic sale side and b) the indexes of import penetration of the corresponding industries. The value of the Spearman correlation is 0.65 and the null hypothesis that these two variables are independent is rejected at the 1 per cent level of statistical significance.

Moreover, focusing on the effects through the cost side, we point to differences across firms in the degree of substitutability between imported intermediate inputs and domestically produced inputs. For example, after a severe depreciation that increases the price of imported inputs in the domestic currency, a firm may decide to replace its imports of intermediate goods with similar goods that are domestically produced. Arguably, the extent to which this happens is likely to reflect technological and organizational characteristics of the firm, that to some extent are shared by the firms in the same industry. If the extent of this substitutability is relatively high (low), then the wage sensitivity to exchange rate through the cost side channel would be relatively low (high). To investigate if the different degree of substitutability between types of intermediate inputs introduces a significant source of heterogeneity across industries in the wage responsiveness to exchange rate along the expenditure side, we estimate an equation that is identical to Eq. (19), except for the effect of $\alpha_{it-1}\Delta pmer_t$ on wages being estimated separately for each industry. To do so, we use the dummy variables for each industry $D_j$, as a further multiplicative term of the $\alpha_{it-1}\Delta pmer_t$ term. To ascertain if the differences between the estimated coefficients summarizing the cost-side effects of exchange rate on wages are significant, we performed a Wald test for the null hypothesis that these differences are equal to zero. The value of the test is 68.7 with a p-value of 0.00, indicating that differences across industries in the wage sensitivity through the cost side are statistically significant. To conserve space, we do not report the regression results but we emphasize that the effect of exchange rate on wages through the revenue side continues to be statistically significant (the estimated coefficient of $\chi_{it-1}\Delta peer_t$ is -0.480 with a standard error of 0.239).

## 5.2 Share of Newly Hired Workers and Composition of the Labor Force

We also investigate other feature that may provide a source of heterogeneity across firms in the wage elasticity to exchange rate. A first aspect deals with the transition of a worker from one firm to another and in particular on whether the effect of exchange rate on a worker's wage is affected by being a job stayer or a job changer. Goldberg and Tracy (2003) point to three different channels of transmission of an exchange rate shock to the worker's wage. While the standard channel is the on-the-job wage adjustment in the aftermath of the shock, exchange rate may also influence: a) the likelihood of a job switch and b) the size of the revision of the worker's wage conditional to a job transition. Using micro-labor data on individual employees, they indeed document a significant effect of exchange rate on the amount of the worker's wage adjustment associated with a job switch.

Using our firm-level data, we focus on the hiring rate for each firm in a given year and investigate whether firms that are similar in all dimensions (e.g. international exposure) except for the percentage of newly hired employees in a given year do exhibit a different responsiveness of the (average) wage to an exchange rate shock. A large size of the hiring rate in a given year implies that the firm has among its employees a large share of job changers who have switched job in that year. To appraise the effect of it on the firm's wage sensitivity to exchange rate, we consider an empirical specification which includes the time-varying firm's hiring rate. Specifically, we augment the two interaction terms of the exchange rate variation with each of the firm's international orientation indicators (respectively, $\chi_{it-1}$ and $\alpha_{it-1}$) with the hiring rate, $hirr_{it}$, also. The two key regressors therefore become the following: 1) $\chi_{it-1} \cdot \Delta peer_t \cdot hirr_{it}$ and 2) $\alpha_{it-1} \cdot \Delta pmer_t \cdot hirr_{it}$. Of course, the term $hirr_{it}$ also enters in isolation in the specification, exactly as $\chi_{it-1}$ and $\alpha_{it-1}$ do. The hiring rate is computed as the share of newly hired workers in a given year over the total number of employees (the latter is calculated as the simple average between firm's employment in periods $t$ and $t-1$). Table 6 documents that the wage sensitivity to exchange rate tends to increase with the rate of firm's hiring in a given year. Indeed, we estimate that the higher is $hirr_{it}$ the stronger is the wage responsiveness to the currency shock along both transmission channels related to the firm's foreign exposure (the one though foreign sales and the one through imported intermediate inputs). For example, if we focus on labor compensation per employee, the estimated effect of exchange rate on the export side is negative and statistically significant (-3.875 with a standard error of 1.097) and the one on the imported input side is positive and significant (9.765 with a standard error of 3.495). Although a thorough investigation of this issue would require data at both the firm and the individual worker level, we argue that our finding on firm's data complements the one uncovered by Golberg and Tracy (2003) on individual workers data not controlling for firms' characteristics.

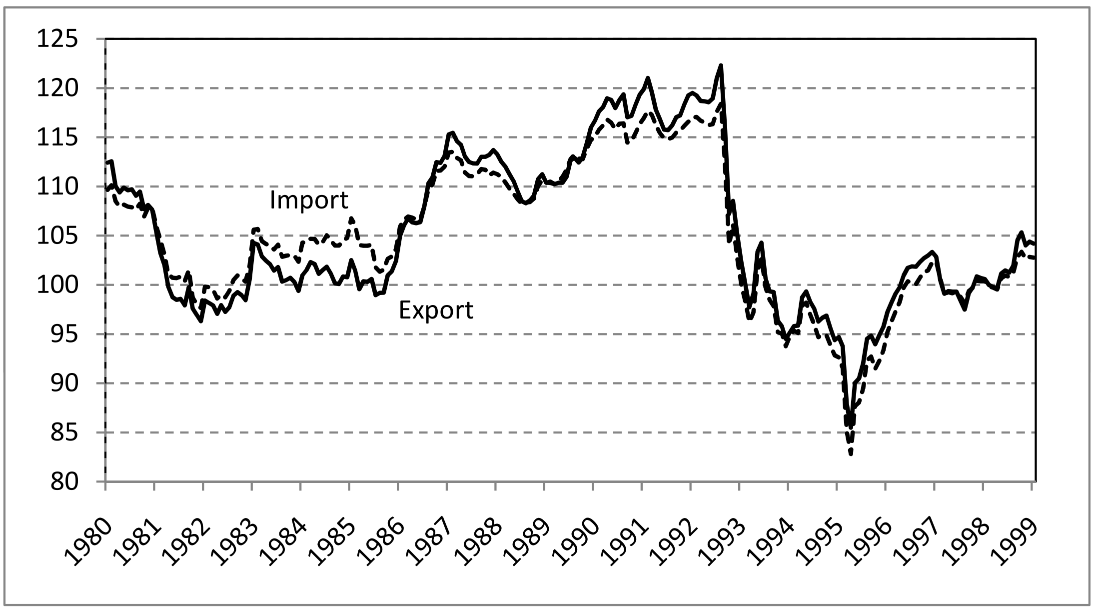
Finally, we focus on the composition of the firm's workforce by type of employees and ask ourselves whether this affects the wage sensitivity to currency swings. We find that it does. In particular, although our data do not provide information on the characteristics of individual worker, we have however information for each firm and in each year on the composition of the firm's workers by type (blue-collar vis-a-vis white collars). Hence, similarly to CG (2001) and NP (2010) we estimate a simple panel specification in which the estimated firm-specific exchange rate elasticities of wages is regressed on the firm's share of blue-collar employees over total workers. The dependent variable is derived from the results of table 1 (column 1) as $(2.608 \cdot \alpha_{it-1} - 0.722 \cdot \chi_{it-1})$. The results are reported in table 7 and, perhaps not surprisingly, they indicate that a higher incidence in the firm of the blue-collar employees (vis-a-vis the white-collars) is conducive to lower estimated wage sensitivity to exchange rate fluctuations.

# 6 Concluding Remarks

Using data on a representative panel of manufacturing firms we find that exchange rate fluctuations do affect the labor compensation set by each firm. Similarly to the analysis in NP (2010) on the response of employment conducted on the same microeconomic data, we find that the direction and size of wage adjustment is determined by the external orientation of each firm on both the revenue and cost side of its balance sheet. Through the revenue side, a currency depreciation affects firm's profitability and thereby the equilibrium outcome of wages. The latter are shown to rise along this channel and the effect is estimated to be larger the higher is the firm's exposure to revenues from exporting. On the other hand, a depreciation leads to a reduction of the firm's wages through the channel of expenditure for imported inputs and the effect is larger the higher is the firm's reliance on imported inputs vis-a-vis domestically produced inputs. Our results indicate that, for a given type of firm's international exposure, the responsiveness of wages to exchange rate is more pronounced for firms with a lower degree of pricing power. Moreover, to provide further characterizations of the wage sensitivity, we also document that other transmission channels introduce a significant source of heterogeneity across firms in the response of wages to exchange rate swings. These include the extent of competition in the domestic marked exerted by foreign producers, as measured by the import penetration in the domestic industry to which a firm belongs. Second, we consider the extent of substitutability in firm's production between imported intermediate inputs and domestically produced inputs. We also analyze the percentage of newly hired workers of a firm in a given year and document that a larger presence in the firm of job changers affects the size of wage adjustment in response to exchange rate variations. Finally, we find that the composition by type of the firm's labor force does influence the exchange rate elasticity of wages, with the latter being larger the higher is the incidence in the firm of white-collar employees.

Figure 1

Real import and export exchange rates (1998 = 100)




Source: Bank of Italy.

Table 1: The Effect of Exchange Rate Change on Wages

| Variable | (1) Labor compensation per employee: $\Delta w_{it}$ | (2) Labor compensation per hour: $\Delta wh_{it}$ |
|---|---|---|
| $\alpha_{it-1} \cdot \Delta pmer_t$ | $2.608^{**}$ | $0.661^{**}$ |
| | (0.753) | (0.336) |
| $\chi_{it-1} \cdot \Delta peer_t$ | $-0.722^{**}$ | $-0.760^{**}$ |
| | (0.140) | (0.162) |
| $\alpha_{it-1}$ | $0.251^{**}$ | $0.263^{**}$ |
| | (0.036) | (0.047) |
| $\chi_{it-1}$ | $-0.004$ | $-0.003$ |
| | (0.003) | 0.004 |
| $MKUP_{it-1}$ | $0.126^{**}$ | $0.053^{**}$ |
| | (0.013) | (0.016) |
| $\Delta s_{it-1}$ | 0.001 | $-0.011^{**}$ |
| | (0.003) | (0.004) |
| $\Delta l_{it-1}$ | $0.046^{**}$ | $0.069^{**}$ |
| | (0.009) | (0.012) |
| Constant | $-0.045^{**}$ | $-0.018$ |
| | (0.010) | (0.012) |
| Year dummies | 809.4 (0.0) | 192.1 (0.0) |
| Industry dummies | 168.9 (0.0) | 117.6 (0.0) |
| Geography dummies | 10.0 (0.0) | 3.8 (0.4) |
| Firm size dummies | 12.7 (0.0) | 26.5 (0.0) |
| Hansen test of over-identifying restrictions: | 283.5 (0.13) | 276.8 (0.20) |
| Test for second-order serial correlation | 1.26 (0.21) | 0.81 (0.42) |
| Number of observations | 6,580 | 6,447 |

Notes: The system GMM dynamic panel methodology is used for estimation. $\alpha_{it-1}$ is the share of expenditure for imported inputs and $\chi_{it-1}$ is the export share of sales. $\Delta pmer_t$ and $\Delta peer_t$ are the (log) changes in the permanent component of, respectively, the import and export exchange rate. $\Delta \mathrm{s}_{it-1}$ is the (log) variation of real sales and $MKUP_{it-1}$ is the firm's mark-up ratio. $\Delta \mathrm{l}_{it-1}$ is the (log) variation of labor input and is measured as number of employees in column 1 and as number of hours in column 2. Size dummies refer to these sizes: 50-99, 100-199, 200-499, 500-999, $\geq$1000 employees. Geographic dummies refer to North-West, North-East, Center, South, Islands. For each group of dummies we report the value of Wald test of their joint significance and the associated p-value. Standard errors are corrected for heteroskedasticity and reported in parentheses. The instrument set includes lagged values of changes of labor inputs, sales and the mark-up dated t-2 and earlier. Hansen is a test of over-identifying restrictions asymptotically distributed as a $\chi^2$. We also report the value of the test for second-order autocorrelation of the differenced residuals (the p-values are reported in parenthes). Sample period: 1984-1998. $^{**}$ denotes significance at the 5% confidence level and $^{*}$ at the 10%.

Table 2: Exchange rate, Market Power and Wage Adjustment (I)

| Variable | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | Compensation per employee: $\Delta w_{it}$ | | Compensation per hour: $\Delta wh_{it}$ | |
| | Degree of market power | | Degree of market power | |
| | Low | High | Low | High |
| $\alpha_{it-1} \cdot \Delta pmer_t$ | $2.848^{**}$ | $2.743^{**}$ | $3.751^{**}$ | $0.528^{**}$ |
| | (0.819) | (0.891) | (1.204) | (0.318) |
| $\chi_{it-1} \cdot \Delta peer_t$ | $-1.281^{**}$ | $-0.375^{**}$ | $-1.182^{**}$ | $-0.302^{**}$ |
| | (0.163) | (0.170) | (0.229) | (0.137) |
| $\alpha_{it-1}$ | $0.368^{**}$ | $0.215^{**}$ | $0.366^{**}$ | $0.285^{**}$ |
| | (0.055) | (0.049) | (0.068) | (0.048) |
| $\chi_{it-1}$ | $-0.007$ | $-0.001$ | $-0.007$ | 0.001 |
| | (0.005) | (0.004) | (0.006) | (0.005) |
| $\Delta s_{it-1}$ | $0.016^{**}$ | $-0.016^{**}$ | $-0.006^{**}$ | $-0.018^{**}$ |
| | (0.003) | (0.004) | (0.003) | (0.003) |
| $MKUP_{it-1}$ | $0.127^{**}$ | $0.168^{**}$ | $0.114^{**}$ | $0.194^{**}$ |
| | (0.012) | (0.034) | (0.015) | (0.027) |
| $\Delta l_{it-1}$ | $0.083^{**}$ | $-0.015$ | $0.147^{**}$ | 0.072 |
| | (0.010) | (0.014) | (0.009) | (0.009) |
| Constant | $-0.053^{**}$ | $-0.051^{**}$ | $-0.006$ | $-0.058^{**}$ |
| | (0.013) | (0.015) | (0.019) | (0.015) |
| Year dummies | 430.2 (0.0) | 489.3 (0.0) | 121.0 (0.0) | 210.3 (0.0) |
| Industry dummies | 76.2 (0.0) | 85.1 (0.0) | 36.5 (0.0) | 137.3 (0.0) |
| Geography dummies | 14.0 (0.0) | 15.7 (0.0) | 15.2 (0.0) | 18.9 (0.0) |
| Firm size dummies | 6.8 (0.2) | 10.0 (0.0) | 12.5 (0.0) | 24.4 (0.0) |
| Hansen test of over-identifying restrictions | 260.9 (0.16) | 210.5 (0.09) | 248.8 (0.17) | 275.5 (0.22) |
| Test for second-order serial correlation | 1.18 (0.24) | 1.82 (0.07) | 0.60 (0.55) | $-0.54$ (0.59) |
| Number of observations | 3,335 | 3,245 | 3,123 | 3,212 |

Notes: see Table 1. The system GMM dynamic panel methodology is used for estimation. The sample is split based on the degree of firms'market power. The threshold criterion is the median of firms'mark-up. Variables in lower-case letters denote their logarithmic transformation. ** denotes significance at the 5% confidence level and * at the 10% level.

Table 3: Exchange rate, Market Power and Wage Adjustment (II)

| Variable | Real Wages: $\Delta w_{it}$ | |
|---|---|---|
| | (1) | (2) |
| | Labor compensation per employee: $\Delta w_{it}$ | Labor compensation per hour: $\Delta wh_{it}$ |
| $\alpha_{it-1} \cdot \Delta pmer_t \cdot (1 - MKUP_{it-1})$ | $2.461^{**}$ | $0.706^{**}$ |
| | (0.848) | (0.342) |
| $\chi_{it-1} \cdot \Delta peer_t \cdot (1 - MKUP_{it-1})$ | $-1.100^{**}$ | $-0.513^{**}$ |
| | (0.184) | (0.163) |
| $\alpha_{it-1}$ | $0.248^{**}$ | $0.244^{**}$ |
| | (0.040) | (0.044) |
| $\chi_{it-1}$ | $-0.005$ | 0.001 |
| | (0.004) | (0.004) |
| $\Delta s_{it-1}$ | $-0.001$ | $-0.003$ |
| | (0.004) | (0.004) |
| $MKUP_{it-1}$ | $0.141^{**}$ | $0.052^{**}$ |
| | (0.016) | (0.015) |
| $\Delta l_{it-1}$ | $0.048^{**}$ | 0.083 |
| | (0.011) | (0.012) |
| Constant | $-0.048^{**}$ | $-0.014$ |
| | (0.010) | (0.011) |
| Year dummies | 576.2 (0.00) | 187.0 (0.00) |
| Industry dummies | 142.0 (0.00) | 62.3 (0.00) |
| Geography dummies | 11.2 (0.02) | 3.7 (0.45) |
| Firm size dummies | 9.9 (0.04) | 20.6 (0.00) |
| Hansen test of over-identifying restrictions: | 229.3 (0.09) | 275.1 (0.22) |
| Test for second-order serial correlation | 1.29 (0.20) | 0.74 (0.46) |
| Number of observations | 6,579 | 6,220 |

Notes: see Table 1. The system GMM dynamic panel methodology is used for estimation. Variables in lower-case letters denote their logarithmic transformation. $^{**}$ denotes significance at the 5% confidence level and $^{*}$ at the 10% level.

Table 4: Exchange Rate, Import Penetration and Wage Adjustment

| Variable | Labor compensation per employee: $\Delta w_{it}$ |
|---|---|
| $\alpha_{it-1} \cdot \Delta pmer_t$ | $5.809^{**}$ |
| | (2.482) |
| $\chi_{it-1} \cdot \Delta peer_t$ | $-2.130^{**}$ |
| | (1.0841) |
| $(1-\chi_{it-1}) \cdot \Delta peer_t \cdot IP_{1t-1} \cdot D_1$, $(1-\chi_{it-1}) \cdot \Delta peer_t \cdot IP_{2t-1} \cdot D_2$,.... ...,$(1-\chi_{it-1}) \cdot \Delta peer_t \cdot IP_{Kt-1} \cdot D_K$ | Wald test: 40.3 ($p$-val: 0.00) |
| $\alpha_{it-1}$ | $0.120^{*}$ |
| | (0.063) |
| $\chi_{it-1}$ | $-0.009^{*}$ |
| | (0.005) |
| $\Delta s_{it-1}$ | $-0.001$ |
| | (0.004) |
| $MKUP_{it-1}$ | $0.033^{**}$ |
| | (0.014) |
| $\Delta l_{it-1}$ | $-0.017$ |
| | (0.016) |
| Constant | $-0.009$ |
| | (0.031) |
| Year dummies | 219.0 (0.00) |
| Industry dummies | 52.8 (0.00) |
| Geography dummies | 11.9 (0.02) |
| Firm size dummies | 5.2 (0.27) |
| Hansen test of over-identifying restrictions: | 175.2 (0.40) |
| Test for second-order serial correlation | 1.50 (0.13) |
| Number of observations | 5,183 |

Notes: see Table 1. The system GMM dynamic panel methodology is used for estimation. $\mathrm{IP}_{jt}$ is the value of import penetration experienced by industry $j$ (to which firm i belongs) in the year $t$. $\mathrm{D}_j$ is the $j$-th industry dummy, taking the value of one if firm $i$ belongs to industry $j$ and zero otherwise. The Wald statistic associated with the variables $(1-\chi_{it-1}) \cdot \Delta peer_t \cdot IP_{jt-1} \cdot D_j$ ($j$=1,2,..., $K$) tests for the joint hypothesis that their coefficients are equal. Variables in lower-case letters denote their logarithmic transformation. $^{**}$ denotes significance at the 5% confidence level and $^{*}$ at the 10% level.

Table 5

Import Penetration across Industries and the Sensitivity of Wage to Exchange Rate

| Industry | Import penetration | | Wage Response through import penetration | |
|---|---|---|---|---|
| | Value | Rank | Estimate | Rank |
| Transformation of non metalliferous minerals | 0.10 | 14 | 0.77 | 13 |
| Chemicals | 0.35 | 3 | −1.08 | 6 |
| Metals | 0.05 | 15 | −1.00 | 7 |
| Machinery for industry and agriculture | 0.25 | 5 | −0.61 | 9 |
| Computers, office equipments, precision instruments | 0.58 | 1 | −1.67 | 2 |
| Electrical machinery | 0.29 | 4 | −2.21 | 1 |
| Motor-cars and other transport equipments | 0.54 | 2 | −1.46 | 3 |
| Food and tobacco products | 0.16 | 7 | −1.19 | 5 |
| Textiles | 0.16 | 8 | −0.49 | 11 |
| Leather and footwear | 0.17 | 6 | −1.19 | 4 |
| Clothing | 0.14 | 12 | −0.56 | 10 |
| Wood and furniture | 0.15 | 11 | −0.13 | 12 |
| Paper and publishing | 0.12 | 13 | −0.73 | 8 |
| Rubber and plastic products | 0.15 | 9 | 0.97 | 14 |
| Other manufactures | 0.15 | 10 | 1.39 | 15 |

Notes: To derive import penetration for each industry and the industry-specific estimated response of wages to exchange rate through import penetration see the discussion in the text. The industry-specific wage responses are obtained from the estimation results documented in Table 4; the ranks of these estimated effects pertains to their absolute values.

Table 6

Exchange rate, Newly Hired Workers and Wage Adjustment

| Variable | Real Wages: $\Delta w_{it}$ | |
|---|---|---|
| | (1) | (2) |
| | Labor compensation per employee: $\Delta w_{it}$ | Labor compensation per hour: $\Delta wh_{it}$ |
| $\alpha_{it-1} \cdot \Delta pmer_t \cdot hirr_{it}$ | $9.765^{**}$ | $8.246^{**}$ |
| | (3.495) | (3.416) |
| $\chi_{it-1} \cdot \Delta peer_t \cdot hirr_{it}$ | $-3.875^{**}$ | $-4.508^{**}$ |
| | (1.097) | (1.391) |
| $hirr_{it}$ | $-0.007$ | $-0.020$ |
| | (0.007) | (0.007) |
| $\alpha_{it-1}$ | $0.254^{**}$ | $0.247^{**}$ |
| | (0.037) | (0.047) |
| $\chi_{it-1}$ | $-0.002$ | $-0.001$ |
| | (0.003) | (0.004) |
| $\Delta s_{it-1}$ | 0.001 | $-0.008^{**}$ |
| | (0.003) | (0.004) |
| $mkup_{it-1}$ | $0.121^{**}$ | $0.051^{**}$ |
| | (0.013) | (0.016) |
| $\Delta l_{it-1}$ | $0.043^{**}$ | $0.065^{**}$ |
| | (0.001) | (0.013) |
| Constant | $-0.045^{**}$ | $-0.010$ |
| | (0.010) | (0.012) |
| Year dummies | 807.2 (0.00) | 195.2 (0.00) |
| Industry dummies | 190.7 (0.00) | 116.9 (0.00) |
| Geography dummies | 7.1 (0.13) | 3.5 (0.47) |
| Firm size dummies | 9.7 (0.05) | 25.0 (0.00) |
| Hansen test of over-identifying restrictions: | 279.9 (0.17) | 275.6 (0.22) |
| Test for second-order serial correlation | 1.20 (0.23) | 0.82 (0.41) |
| Number of observations | 6,580 | 6,447 |

Notes: see Table 1. The system GMM dynamic panel methodology is used for estimation. Variables in lower-case letters denote their logarithmic transformation. $hirr_{it}$ is the hiring rate as defined in the text. $^{**}$ denotes significance at the 5% confidence level and $^{*}$ at the 10% level.

Table 7

Workers Type and the Response of Wage to Exchange Rate

| | Dependent variable: Estimated Wage Response (see table 1) $2.608 \cdot \alpha_{it-1} - 0.722 \cdot \chi_{it-1}$ |
|---|---|
| Variable | |
| $\frac{Num\_Blue\ Collars_{it}}{Num\_Total_{it}}$ | $-0.062^{**}$ |
| | (0.014) |
| Constant | $-0.061$ |
| | (0.061) |
| Year dummies | 129.0 (0.00) |
| Industry dummies | 9.5 (0.00) |
| Geography dummies | 0.3 (0.86) |
| Firm size dummies | 6.4 (0.00) |
| Hausman test | 288.4 (0.00) |
| Number of observations | 9,950 |

Notes: The dependent variable is the estimated response of compensation per employee to permanent exchange rate variations as obtained by estimating the equation whose results are documented in Table 1 (column 1). The explanatory variable is the firm-level share of blue-collar workers over total workers. The fixed effects panel estimation method has been applied and values of the Hausman test are reported (with the associated p-value). $^{**}$ denotes significance at the 5% confidence level and $^{*}$ at the 10% level.

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