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AND THE ROLE OF REAL EXCHANGE  
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ANALYSIS**

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## ABSTRACT

### Manufacturing restructuring and the role of Real exchange rate shocks: A firm level analysis\*

Empirical analyses of the impact of real exchange rate (RER) fluctuations on employment and economic performance do not take heterogeneity with respect to trade exposure into account. In this paper we use detailed Norwegian firm-level data on exports and imports to calculate firm-specific measures of trade exposure. This allows us to provide a more accurate assessment of the adjustment to real exchange rate shocks. We treat the sharp real appreciation of the Norwegian Krone in the early 2000s as a natural experiment to identify firms' response to an RER shock with respect to employment, productivity, and offshoring. We find that the relative cost shock that hit the Norwegian economy led to a significant decline in the more exposed firms' employment. But the RER shock also appears to have contributed to a process of manufacturing restructuring that boosted productivity of firms exposed to foreign markets. A sizable increase in offshoring can also be attributed to the RER shock.

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# 1 Introduction

Real appreciations are typically feared by export industry representatives as well as governments for their potential negative influence on profitability and employment. However, mounting evidence that firms' exposure to trade varies significantly even within export industries implies that firms may be hit very differently by a real exchange rate (RER) shock. Often firms with a large share of exports in total sales also import a large share of their intermediate inputs, implying that a real appreciation has ambiguous effects on profitability.<sup>1</sup> Previous empirical analyses of the impact of RER fluctuations on employment and economic performance have failed to account for heterogeneity in exports as well as imports. As a result, the effects of RER shocks may not have been correctly estimated.

Using a new and extensive micro data set for Norwegian manufacturing with detailed information on firms' exports as well as imports of intermediates, we are able to calculate precise measures of trade exposure. In doing this, we are able to overcome one severe shortcoming of previous studies of the impact of RER fluctuations; the lack of detailed, firm-specific measures of trade exposure. Moreover, a sharp real appreciation of the Norwegian Krone in the early 2000s lends itself as a natural experiment to study the causal impact of RER shocks on employment and manufacturing restructuring.

The central bank of Norway adopted inflation targeting in March 2001. This was followed by very high wage settlements. In order to comply with the inflation target, the response of the central bank was to increase the interest rate, creating a large gap vis-à-vis foreign rates. This gap was further enlarged as the Federal Reserve Bank and the European Central Bank lowered their interest rates as the dot com bubble burst. As a consequence the Norwegian Krone appreciated sharply. Prior to the year 2000 the real exchange rate had been rather stable, but between 2000 and 2002 the real exchange rate rose by around 17 per cent<sup>2</sup> (see Figure 1).

By the end of 2004 around 32 000 manufacturing jobs had been eliminated, implying that manufacturing employment had declined by 11 per cent compared to the year 2000. The Norwegian central bank was widely criticized for not paying enough attention to the exchange rate in this period, and blamed for the sharp decline in manufacturing employment. Amongst the critical voices was the OECD, which noted in its annual country report

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<sup>1</sup>The correlation between export and import share for firms with positive exports and imports was 0.71 in 2004.

<sup>2</sup>Measured by relative hourly wages costs for workers in manufacturing in Norway relative to major trading partners, denominated in a common currency. Other measures of the RER, e.g. from OECDs MEI (2008), show very similar trends.

of Norway in 2004 that "the monetary policy stayed too tight for too long".<sup>3</sup>

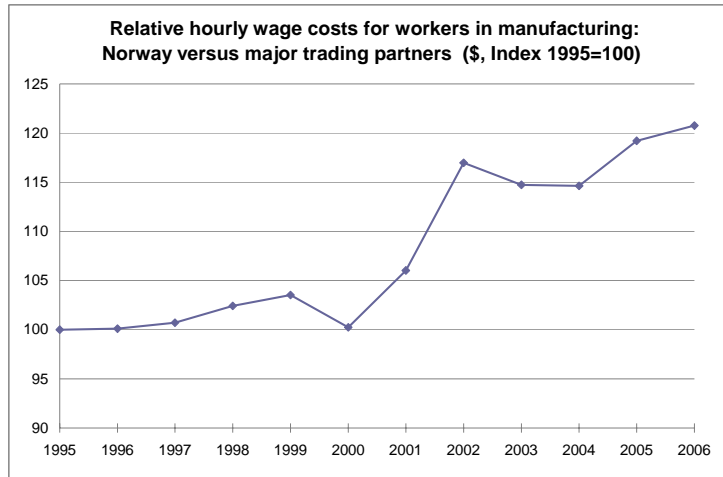


Figure 1: The Norwegian RER-shock 2000-2002

From a methodological point of view, the main contribution of this paper is that we allow a change in the real exchange rate to have different effects on different types of firms depending on their exposure to trade. Recent theoretical and empirical contributions stress the importance of taking intra-industry firm heterogeneity into account when studying structural adjustment to changes in the trading environment (see Melitz, 2003, and Bernard et al., 2007). Firms within the same industry are found to differ significantly in size, productivity and trade exposure. In order to fully understand how the economy adjusts to real exchange rate shocks it is thus necessary to study the impact at a disaggregated level.

Previous studies of the employment effects of real exchange rate movements include Burgess and Knetter (1998), Branson and Love (1988), Campa and Goldberg (2001), Gourinchas (1999), and Klein et al. (2003). While some of these studies are based on firm-level data on employment, measures of trade exposure have all been calculated using industry-level information. Our micro data set for Norwegian manufacturing firms includes detailed information on firms' exports as well as imports of intermediates, and allows us to account for firm heterogeneity and the two opposing effects of a real appreciation on profitability: a negative effect due to decreased competitiveness

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<sup>3</sup>See OECD (2004).

in export markets (which translates into a decreased export price in domestic currency for firms operating as price takers) and a positive effect due to reduced costs as imported inputs become cheaper in domestic currency.

Moreover, our data allow us not only to assess the impact of a RER shock on employment, but also on manufacturing restructuring. There are a number of ways in which firms may respond to the decreased competitiveness in foreign markets that a RER appreciation brings. For instance, firms may act to improve efficiency if there is some slack at the outset. Moreover, they may take the opportunity of purchasing cheaper inputs from abroad, thereby contributing to increased offshoring of intermediate input production. Partly, this may occur through foreign direct investment (FDI), i.e. through firms setting up foreign subsidiaries producing inputs that are used by the parent firm. Another possible response is FDI in assembly activities, which may make later stages in the production process cheaper compared to maintaining them at home. To examine how the firms respond to a RER shock we study how the appreciation of the Norwegian Krone affected firms' productivity and their strategies regarding offshoring of intermediate input production and FDI.

Several conclusions emerge from the analysis. First, the RER shock was associated with a substantial loss of manufacturing employment. One seventh of the total decline in manufacturing employment over the studied period can be attributed to the real appreciation. Second, the shock led to productivity gains at the firm level, indicating that the firms being most exposed to the shock were able to improve efficiency in the face of tougher market conditions. We do not find any evidence of more exposed firms having a higher probability of exiting, after controlling for firm characteristics. Hence, increases in productivity at the industry level appear to have been driven by within-firm increases rather than by between-firm reallocation. Third, firms responded by sourcing a greater share of their inputs from abroad, thereby contributing to increased offshoring. For the manufacturing industry as a whole, the real appreciation increased offshoring, as measured by the import share, by about one and a half percentage points.

The rest of the paper is organized as follows: We first provide a brief review of related literature in section 2. In section 3 we then lay out our identification strategy, describe the estimation procedure and present the data. In section 4 we present and discuss our empirical results. Finally, section 5 concludes.

## 2 Related Literature

Volatility in nominal exchange rates leads to volatility in real exchange rates since prices tend to be sticky. As is well known, deviations from purchasing power parity can be large as well as persistent.<sup>4</sup> Therefore it is important to understand how real exchange rate shocks affect the economy. Real depreciations are expected to have a positive effect on exports and on the relative attractiveness of domestic versus foreign production locations. Real appreciations are, on the other hand, typically expected to reduce investment and even lead to firm closure on account of their impact on relative cost levels. However, it is unclear whether real exchange rate changes really have these effects on output and investment (see e.g. Goldberg et al, 1999). Real appreciations lead to lower prices on imported inputs in domestic currency and may therefore benefit production with a high import content (while real depreciations have the opposite effect). Furthermore, the positive effect on the distribution of wealth from a real appreciation may lead to increased investment in domestic assets (Goldberg et al., 1999).

Most of the previous literature is based on industry-level analysis. A number of papers have examined the impact of RER changes on employment and job reallocation at the industry level. Studies of the effect of RER changes on net employment include Branson and Love (1988) and Burgess and Knetter (1996), while studies of the effect on gross job flows include Davis et al. (1996), Gourinchas (1998). and Klein et al. (2003).

As recent theoretical and empirical studies have shown, firms vary significantly along several dimensions – trade exposure, productivity and size – even within industries.<sup>5</sup> This implies that estimates based on industry-level data may not accurately capture the true impact of RER shocks on firms exposed to international trade. However, only a few papers have used firm-level data to examine the effect of RER changes. Gourinchas (1999) study the impact of RER movements on net and gross job flows in French manufacturing, finding that traded-sector industries are very responsive to RER movements. He does not study the impact on firm response regarding other potential margins of adjustment, such as reducing costs by increasing efficiency or sourcing intermediate inputs from abroad. In a recent study, Fung (2008) use firm-level data for Taiwan to examine how real exchange rate changes affect firm sales and productivity through its exploitation of economies of scale. She emphasizes two counteracting effects of a real appreciation on sales of surviving

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<sup>4</sup>See e.g. Rogoff (1996).

<sup>5</sup>See Melitz, 2003, for the seminal theoretical contribution to this literature, and Bernard et al, 2007, for an overview of the empirical findings on firm heterogeneity in trade.

firms: (i) a negative effect of increased competition from foreign firms and (ii) a positive effect of exit of domestic firms. A fundamental difference compared to our work is that she identifies the composite effect of (i) and (ii), while our firm-level model identifies the direct effect (i). Moreover, she does not analyze how RER shocks affect employment. Her empirical results indicate that a real appreciation leads to within-firm increases in productivity due to an expansion of scale of operations by surviving firms.<sup>6</sup> Fung and Liu (2008) also investigate the impact of real exchange rate movements on exports, sales and productivity in Taiwanese manufacturing while limiting their analysis to firms listed at the Taiwanese stock exchange. However, while basing their analyses on firm level data, all the above studies rely on industry-specific trade-weighted real exchange rates, none of which use information about imported intermediates. Hence, our analysis differs significantly from these as we exploit the firm specific trade data to account for heterogeneity across firms with respect to their net currency exposure.

### 3 Estimation Strategy

#### 3.1 Identification

Previous studies attempting to quantify the effect of real exchange rate movements have mainly used variation in sector-specific RERs to achieve identification (see, e.g., Klein et al., 2003; Gourinchas, 1999). Sector-specific RERs are typically constructed by weighting bilateral RERs by sector-level trade shares. Our approach instead relies solely on the heterogeneity of exposure across firms, treating the change in the RER as equal across sectors.

We believe that our approach has clear advantages. First, when using sector-specific RERs, one makes the stark assumption that goods are priced in the same currency as used in the destination country for exports and source country for imports. This may not always be the case. A recent survey shows that 30 per cent of Norwegian manufacturing firms use USD as the settlement currency in international transactions.<sup>7</sup> However, the export and import share in 2005 to/from the US was only 8 and 5 per cent, respectively.<sup>8</sup> Second, the Norwegian RER shock was quite uniform across destinations. Figure 2 shows the evolution of the nominal exchange rate

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<sup>6</sup>Exit rates of firms were found to be relatively high in Taiwanese manufacturing.

<sup>7</sup>Report from the Federation of Norwegian Industries, <http://www.norskindustri.no/getfile.php/Dokumenter/PDF/Konjunkturrapport%202008trykk.pdf>

<sup>8</sup>Data from Statistics Norway, <http://www.ssb.no/uhaar/tab-20.html>

between the Norwegian Krone and four other currencies and one currency basket.<sup>9</sup> The picture reveals that the change in the nominal exchange rate was very similar vis-à-vis all currencies except USD, which did not recover again after the shock. From an econometric point of view, this means that the variation in (changes in) sector-specific RERs was quite small, leading to weak identification of possible effects of the shock.

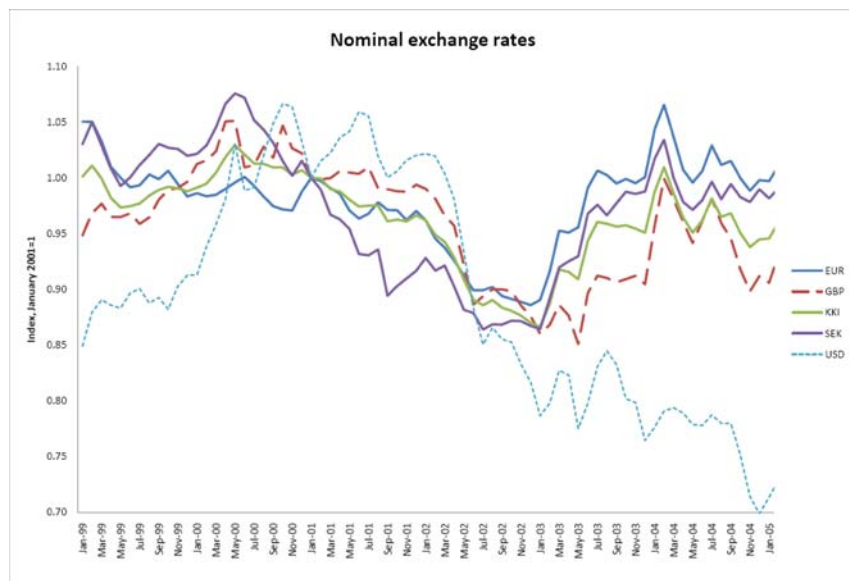


Figure 2: Nominal exchange rates between the Norwegian Krone and other currencies and currency baskets

Third, Campa and Goldberg (2001) point out that there are three distinct channels of exchange rate exposure: (i) the firm's export sales, (ii) import competition faced in the domestic market, and (iii) the firm's purchases of imported inputs. Previous studies have only accounted for the two first channels, while we are able to include the third channel, imported inputs. Finally, there is mounting empirical evidence on the heterogeneity of firms with respect to trade activity. Previous studies ignore this fact as they use industry or sector based measures of trade exposure, while our access to firm-level data allows us to develop firm specific trade exposure measures.

We start by identifying the *net currency exposure* of a firm, which is a measure of the extent to which the firm is affected by a real exchange rate

<sup>9</sup>KKI is a trade weighted exchange rate index, based on OECD's trade weights.

shock. Consider revenue of a firm  $i$ :  $R_i = p_i x_i + V p_i^* x_i^*$ , where  $p_i$  and  $p_i^*$  are prices in local currency set at home and abroad, respectively,  $x_i$  and  $x_i^*$  are sold quantities at home and abroad, respectively and  $V$  is the nominal exchange rate expressed as units of domestic currency per unit of foreign currency. We can rewrite revenue as  $R_i = (x_i + x_i^*/P_i) p_i$ , where  $P_i$  is the real exchange rate (RER),  $P_i \equiv p_i/V p_i^*$ . An increase in  $P_i$  implies a real appreciation. The elasticity of revenue with respect to  $P_i$  is

$$\frac{\partial R_i}{\partial P_i} \frac{P_i}{R_i} = -\frac{V p_i^* x_i^*}{R_i} \equiv -\lambda_i \quad (1)$$

i.e. it is equal to the firm's export share. For given output and prices, a one percent real appreciation decreases total revenue with  $\lambda_i$  percent.

Symmetrically, we can define firm  $i$ 's costs as  $C_i = q_i v_i + V q_i^* v_i^*$ , where  $q_i$  and  $q_i^*$  are prices in local currency of domestic and imported inputs, respectively, and  $v_i$  and  $v_i^*$  are used quantities of domestic and imported inputs, respectively. We can rewrite costs as  $C_i = (v_i + v_i^*/Q_i) q_i$ , where  $Q_i = q_i/V q_i^*$ . The elasticity of costs with respect to  $Q_i$  is

$$\frac{\partial C_i}{\partial Q_i} \frac{Q_i}{C_i} = -\frac{V q_i^* v_i^*}{C_i} \equiv -\tilde{\lambda}_i \quad (2)$$

i.e. it is equal to the share of imported inputs in total costs. For given inputs and prices, a one percent real appreciation decreases total costs with  $\tilde{\lambda}_i$  percent.

Suppose  $P_i = Q_i$ , implying that the RER measured by output prices is equal to the RER measured by input prices. Then the elasticity of profits ( $\Pi_i$ ) – revenues minus costs – with respect to a change in the real exchange rate can be expressed as:

$$\begin{aligned} \frac{\partial \Pi_i}{\partial P_i} \frac{P_i}{\Pi_i} &= \frac{P_i}{\Pi_i} \left( \tilde{\lambda}_i \frac{C_i}{P_i} - \lambda_i \frac{R_i}{P_i} \right) \\ &= -\lambda_i - \frac{(\lambda_i - \tilde{\lambda}_i)}{\Pi_i/C_i} = -\tilde{\lambda}_i - \frac{(\lambda_i - \tilde{\lambda}_i)}{\Pi_i/R_i}. \end{aligned} \quad (3)$$

Define the *net currency exposure* as the difference between the export share and the share of imported inputs,  $\Lambda_i \equiv \lambda_i - \tilde{\lambda}_i$ . A positive  $\Lambda_i$  implies that the effect on profits of a real appreciation (a rise in  $P_i$ ) is negative, while the effect on profits of a real depreciation (a fall in  $P_i$ ) is positive.<sup>10</sup>

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<sup>10</sup>Three aspects of (3) are worth noting: (i) Net exposure is divided by profit relative to revenue or sales. The profit effect of high-profit firms are, all else equal, less sensitive to the net currency exposure to a real appreciation. (ii) Profits are affected by RER movements

The greater is  $\Lambda_i$ , the more negative the impact on profits of an increase in  $P_i$ . The net currency exposure thus captures the extent to which profits are negatively affected by a real appreciation.

Profits of import-competing firms with zero net exposure may also be affected by RER shocks. For example, a real appreciation might force them to lower prices and/or output because foreign competition becomes more intense. Nevertheless, it is reasonable to assume that, after controlling for firm and industry heterogeneity, profits of firms with higher net currency exposure will be more negatively affected by a real exchange appreciation than firms with lower net currency exposure. This will be our identifying assumption.

Following Campa and Goldberg (1995, 2001), it may also be useful to distinguish between exposure related to the export share (channel (i) above) and exposure related to the share of imported inputs in total costs (channel (iii) above). We refer to the separate exposures on the export and import side as *gross currency exposure*.

With the approach adopted in this paper, we are not able to identify RER effects on firms that neither export nor use imported inputs because their net as well as gross exposure is zero. There are also a few other potential problems with our identification method: (i) Even if  $\Lambda_i = 0$ , the firm may be exposed because revenues and costs are denominated in different currencies. However, for our analysis this is probably less of a problem, since the RER appreciated similarly against most countries. (ii) We do not observe the use of financial derivatives, i.e. to what extent firms hedge currency risk. However, we believe that this will not seriously bias our measure because available evidence suggests that long run ( $> 3$  years) currency hedging is relatively uncommon.<sup>11</sup> Secondly, firms can only hedge against nominal currency shocks, not relative output or input price movements.

### 3.2 Econometrics

In order to estimate the response to the RER shock we use a differences-in-differences approach, similar to Trebler (2004) in his study of the response of Canadian firms to trade liberalization through the NAFTA agreement. We define the years 1999-2000 as the pre-RER-shock period and the years 2002-

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even for a firm with zero net exposure. This is because, as long as profits are positive, revenue is higher than costs. So, a one percent depreciation will have a larger effect on revenues than on costs.(iii) The elasticity of profits is zero when  $\tilde{\lambda}_i (C_i/R_i) = \lambda_i$ , so  $\tilde{\lambda}_i > \lambda_i$  for a firm with positive profits. Again, this is related to the point above, that the optimal import share is higher than the export share because revenue is higher than costs.

<sup>11</sup>See Norges Bank: Penger og Kreditt 1/2005.

2004 as the post-RER-shock period. As there may be some time between the real exchange rate change and firms' response, we leave the year 2001 out of the post-RER treatment period.<sup>12</sup>

We want to analyze the response to the RER shock at firm as well as industry level. Let  $\Delta y_{ijt}$  be the average annual log change in the outcome of interest of firm  $i$ , in industry  $j$ , in period  $t$ . The outcome variable could be employment, productivity or imports of intermediate inputs. Then we can define the average annual log changes in the pre and post shock period as:

$$\begin{aligned}\Delta y_{ij1} &= (\ln Y_{ij2004} - \ln Y_{ij2002}) / (2004 - 2002), \\ \Delta y_{ij0} &= (\ln Y_{ij2000} - \ln Y_{ij1999}) / (2000 - 1999),\end{aligned}\tag{4}$$

where  $t = 0$  denotes the pre-RER shock period, and  $t = 1$  denotes the post-RER shock period. We propose the following model for explaining the impact of the RER shock on the change in performance or structure:

$$\Delta y_{ijt} = \alpha_{ij} + \theta_t + \beta (\Lambda_{ij} \Delta p_t) + \gamma \Delta y_{jt}^{SE} + \varepsilon_{ijt},\tag{5}$$

where  $\Delta y_{ijt}$  is the change in the outcome of interest. The effect of the RER change is assumed to be determined by the interaction term  $(\Lambda_{ij} \Delta p_t)$ , where  $\Lambda_{ij}$  is net currency exposure<sup>13</sup> and  $p_t$  is the log of the RER, where higher  $p_t$  indicates an appreciation. The specification includes a growth fixed effect at the level of the firm,  $\alpha_{ij}$ , a time specific effect capturing economy-wide business conditions (macro shocks),  $\theta_t$ , and idiosyncratic industry demand and supply shocks, proxied by changes in Swedish manufacturing employment  $\Delta y_{jt}^{SE}$  (explained below). Differencing (5) across periods yields our baseline difference-in-difference firm-level specification:

$$\Delta y_{ij1} - \Delta y_{ij0} = \theta + \beta \Lambda_{ij} (\Delta p_1 - \Delta p_0) + \gamma (\Delta y_{j1}^{SE} - \Delta y_{j0}^{SE}) + \phi \mathbf{x}_{ij99} + v_{ij}\tag{6}$$

where  $\theta \equiv \theta_1 - \theta_0$  and  $v_{ij} \equiv \Delta \varepsilon_{ij}$ . Following Treffer (2004), we also add a vector of firm characteristics,  $\mathbf{x}_{ij99}$ , that includes the 1999-value of a set of firm level variables: number of employees, labor productivity (all in logs) and dummy variables indicating whether the firm is exporting and importing. The set of controls also includes two industry-level variables: a measure of skill intensity and import penetration. The latter variable is included to at least partly account for potential bias arising from effects through increased

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<sup>12</sup>It is reasonable to assume that adjusting to a RER shock takes time, so that firms' response will be characterized by a time lag. Labor market and firing regulations impede immediate adjustment of the labor stock, while exports and intermediates imports are typically bound by contracts that cannot be immediately re-negotiated.

<sup>13</sup>To calculate net currency exposure we use data for the first year of observation, 1999.

import competition (channel (ii) in the previous section). The basis for including this variable will be explained in more detail below.

The estimated  $\theta$  will pick up the change in  $\Delta y_{it}$  which is due to the business cycle (economy-wide changes). This coefficient will also pick up the impact of the RER shock in non-trading firms (with  $\Lambda_{ij} = 0$ ). The variable  $(\Delta p_1 - \Delta p_0)$  is defined as the economy-wide change in the real exchange rate and will just be a constant (positive) number across all industries and firms. However, variation in  $\Lambda_{ij}$  will enable us to make inference about  $\beta$ . Suppose  $\Delta y_{ijt}$  is employment growth. If  $\beta < 0$ , the appreciation had a negative impact on employment growth, with exposed firms experiencing a larger decrease, or smaller increase, in employment growth than similar non-exposed firms.

The differenced equation allows for time-invariant heterogeneity in growth rates across firms (the  $\alpha_{ij}$ ). However, there may be variation in growth rates which coincides with our measure of net exposure. For example, it may be that some firms experience worsening worldwide business conditions, and that these conditions are correlated with exposure. To control for idiosyncratic industry shocks – applying worldwide – we use Swedish manufacturing employment data (in logs) represented by  $y_{jt}^{SE}$ . The variable  $y_{jt}^{SE}$  will control for underlying worldwide changes in supply and demand, changes in pricing-to-market behavior, changes in the degree of competition from low-cost countries such as China, and other time-varying industry characteristics. We choose to use Sweden as our control because (i) its RER was relatively stable during the 1999-2004 period and (ii) it is Norway’s largest trading partner and its economy highly integrated with the Norwegian one (not only regarding goods and capital markets, but regarding the labor market as well).

As already mentioned, our identification strategy implies that RER effects through import competition - for example arising because mark-ups of import-competing firms are squeezed due to tougher foreign competition - are not identified. This can potentially bias our results if there is a systematic relationship between currency exposure and import competition. For example, if the negatively exposed firms ( $\Lambda_{ij} < 0$ ) face a higher degree of import competition than the positively exposed firms, then our estimate of  $\beta$  will be biased downwards. This is why our regressions include a control for industry-level import competition. Import competition is defined as the value of industry imports relative to the value of industry absorption in our base year (1999). We report details about the construction of the import competition variable as well as other variables in appendix.

Our baseline industry-level specification relies on the same model as the firm-level specification:

$$\Delta y_{j1} - \Delta y_{j0} = \theta + \beta \Lambda_j (\Delta p_1 - \Delta p_0) + \gamma (\Delta y_{j1}^{SE} - \Delta y_{j0}^{SE}) + \phi \mathbf{x}_{j99} + v_j \quad (7)$$

where  $\mathbf{x}_{j99}$  represents a vector of similar controls as the ones used in (6). Now, the firm-level variables are measured as weighted averages across the population of firms in each sector and the export and import dummies are replaced by continuous variables measuring exports and imports of the sector.

### 3.2.1 Data

We employ an exhaustive firm-level data set for the Norwegian manufacturing sector. The data set is based on several data sources. To begin with, we use firm data from Statistics Norway's capital database, which is an unbalanced panel of all joint-stock companies spanning the years 1999 to 2004, with approximately 8,000 firms per year.<sup>14</sup> The panel provides information about total revenue, value added, employment, capital stock, wage costs and intermediate costs. In 2004 the data set covered about 90 percent of manufacturing output in Norway. All joint-stock companies are sampled with certainty in the panel.

Information about exports and imports at firm level is assembled from customs declarations. These data make up an unbalanced panel of all yearly exports and imports values by firm. There are in total about 3,000 firms exporting and 5,000 firms importing each year. Total manufacturing exports and imports amounted to approximately 140 and 80 billion NOK in 2004. The trade data have then been merged with the capital database, based on a unique firm identifier.

We also use information on the firms' foreign operations. Data on foreign affiliate sales are gathered from the Directorate of Taxes' foreign company report and comprise all outward FDI stocks and associated affiliate sales in the manufacturing sector in the period 1999 to 2004. Total affiliate sales amounted to over 60 bill. NOK in 2004, but only 0.5 to 1 percent of the population of firms conducted FDI in any given year.<sup>15</sup> Similarly, the FDI data have been merged with the capital database based on a unique firm identifier.

In our sector-level analysis, we have aggregated all observations, including firms which exited and entered during the sample period. Labor productivity, total factor productivity (TFP), net and gross currency exposure are calculated as weighted means, using firm output as weights. Aggregation is carried out at the 5-digit level of the Nace classification. The skill-intensity of

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<sup>14</sup>Statistics Norway's capital database is described in Raknerud *et al.* (2004).

<sup>15</sup>Affiliate sales is here defined as total revenue of the affiliate, adjusted by the parents' ownership share. 20 percent ownership is used to distinguish direct investment from portfolio investment. Direct investment comprises investors' share of equity in foreign companies and investors' debt to and claims on foreign companies.

a sector is measured as the share of workers with post-secondary education. This information is only available at the 2-digit level of Nace.

The firm-level analyses as well as descriptive statistics are based on a balanced panel comprising about 4,800 firms.

### 3.2.2 Terms of trade

One may argue that the effect on imports of intermediate inputs is difficult to assess because the appreciation led to decreased import prices measured in Norwegian currency. When the change in the import share is used as the dependent variable, the estimates will reflect the lower price of imported inputs. In general, this is not a problem in our model because price movements affecting all sectors or firms simultaneously will be subsumed into the  $\theta$  term. A more relevant issue, however, is the possibility that relative price movements between sectors/firms will bias our results. To avoid this, we have deflated export and import values by price deflators at the 2-digit industry level (see appendix for further details).

## 4 Empirical results

### 4.1 Employment

We first present results for the industry level and then results for the firm level, beginning with manufacturing employment and the role played by the RER shock. From 2000 to 2004 manufacturing employment fell by 11 percent. In 12 out of 21 industries (at the 2-digit level of Nace) employment growth declined after the real appreciation, see Table A1 in the appendix for an overview. About 63 percent of the firms experienced a decline in employment growth (measured by number of employees as well as hours worked).

Can this decline in employment growth be linked to net currency exposure? A first quick look at the data suggests "no". We use the net exposure variable to split the firms into two groups: one whose profitability would be hit negatively by a real appreciation (exposed firms) and one whose profitability would be unaffected or hit positively by a real appreciation (non-exposed firms). It turns out that 20 percent of the firms are exposed. Out of these, 62 percent reported a decline in employment growth. However, looking at the firms with a negative net currency exposure, thus defined as non-exposed, the figure is nearly the same, with 64 percent reporting a decline in employment growth.

But once we start controlling for other firm characteristics, the picture changes. Table 1 provides an overview of firms' employment growth before

and after the RER shock depending on their size, skill intensity and net currency exposure. As is clear from the table, for the most part, there was negative employment growth both before and after the shock. However, comparing the growth rates before and after, we see the following pattern: (i) employment growth increased more (or decreased less) at large firms than at small firms; (ii) employment growth increased more (or decreased less) at firms operating in skill-intensive sectors than at other firms; and, most importantly, (iii) employment growth decreased more at exposed firms than at non-exposed firms – except for when firms were large and operating in skill-intensive sectors. For the latter group, the opposite is found to be true since employment growth increased more than at non-exposed firms.

**Table 1: Firm characteristics and employment growth**

Firm size	Exposed	Skill-intensity	No. of firms	$\Delta y_{i0}$	$\Delta y_{i1}$	$\Delta y_{i1} - \Delta y_{i0}$
Small	No	Low	2069	-0.7	-5.3	-4.6
Small	Yes	Low	392	0.2	-5.6	-5.8
Small	No	High	965	-6.6	-2.2	4.4
Small	Yes	High	124	1.1	-4.3	-5.4
Large	No	Low	617	-1.9	-2.1	-0.2
Large	Yes	Low	356	-0.6	-3.1	-2.5
Large	No	High	251	-6.6	-4.0	2.6
Large	Yes	High	81	-5.4	-2.2	3.2

Note:  $\Delta y_{i0}$ : employment growth 1999-2000;  $\Delta y_{i1}$ : employment growth 2002-2004; Firm size: Small:  $\leq 20$  employees, Large:  $> 20$  employees; Exposed: No:  $\Lambda \leq 0$ , Yes:  $\Lambda > 0$ ; Skill-intensity: Low:  $< .18$ , High:  $\geq .18$ .

Turning to the econometric analysis, we first analyze the impact of the RER shock at the industry level (5-digit level of Nace). Based on traditional trade theory, we expect trade and specialization patterns to be determined by comparative advantage, leading industries to be hit differently by a real appreciation. Industries with strong net exports are expected to be more adversely hit than other industries. Table A1 in the appendix, which provides an overview of trade exposure and employment growth at the industry level, shows that industries vary significantly in their trade exposure. The results from estimating (7) using employment as dependent variable – measured in terms of number of man hours (*hours*) – are reported in Table 2. Columns 1 and 2 show results using net exposure  $\Lambda_i$  as RHS variable, while in columns 3 and 4, we have used gross export and import exposure as explanatory variables. Both specifications are reported with and without control sets (average firm size, weighted average productivity, and weighted average exports and

imports). All in all, our results indicate that the RER shock does not appear to have had any significant impact on employment growth. This holds true both with and without the set of industry controls. In other words, currency exposure did not matter for employment growth at the industry level. Nor do we find any robust systematic variation in employment growth linked to any of the control variables.

**Table 2: Industry level: Employment growth 99-00 vs. 02-04**

	OLS (1a)	OLS (1b)	OLS (2a)	OLS (2b)
Net exposure $\Lambda$	2.151 (2.992)	3.578 (2.269)		
E exposure $\lambda$			2.369 (3.044)	3.500 (2.276)
I exposure $\tilde{\lambda}$			-2.847 (3.441)	-2.827 (2.627)
ln(firm size 99)	-0.036 (0.041)		-0.040 (0.042)	
ln(labprod 99)	0.000 (0.098)		-0.003 (0.098)	
ln(skill intensity)	0.019 (0.080)		0.018 (0.080)	
ln(exports 99)	0.030 (0.028)		0.028 (0.029)	
ln(imports 99)	0.013 (0.038)		0.019 (0.041)	
ln(imp. comp)	-0.051 (0.058)		-0.048 (0.058)	
ln(Swe control)	0.137 (0.177)		0.136 (0.177)	
No. of obs.	202	217	202	217

Note: The dependent variable is  $\Delta y_{j1} - \Delta y_{j0}$  with  $\Delta y_{jt}$  defined as in (4) with  $Y_{jt}$  representing employment in terms of man hours.

Since firms within an industry are heterogeneous with respect to their exposure to trade – and we expect them to be so from the theory of trade and firm heterogeneity – we need to analyze the impact of the RER shock at the firm level. Table 3, column (1a) reports the results from estimating (6) using firm-level employment growth as dependent variable.<sup>16</sup> It turns out that the RER shock had a significant impact on firm-level employment measured in terms of man hours. The greater net exposure, the greater the decline in employment growth. We also investigate the marginal impact of export and import exposure separately. According to theory, the estimated export coefficient should be equal to the negative of the import coefficient. Column (2a) shows that export exposure is significant and has the expected

<sup>16</sup>Note that while we use the weighted average export and import level in 1999 as controls in the industry-level regressions presented in Table 2, in the firm-level regressions we use a dummy indicating whether a firm is exporting/importing instead. If we were to use logs of levels of exports and imports we would have to exclude all firms that do not trade from the sample, which could potentially produce a selection bias.

sign, while import exposure has the expected positive sign but is not significantly different from zero. We also see that larger and skill-intensive firms experienced a smaller decline in employment growth. Columns (1b) and (2b) report OLS results from models excluding all controls, and the estimates underscore the robustness of the results: the coefficients for currency exposures remain very similar across the different specifications.

**Table 3: Firm level: Employment growth, 99-00 vs. 02-04**

	OLS (1a)	OLS (1b)	ML-HS (1c)	OLS (2a)	OLS (2b)	ML-HS (2c)
Net exposure $\Lambda$	-1.099** (0.437)	-0.834** (0.416)	-0.869** (0.434)			
E exposure $\lambda$				-1.184*** (0.445)	-0.908** (0.422)	-0.915*** (0.439)
I exposure $\tilde{\lambda}$				0.802 (0.527)	0.518 (0.506)	0.694 (0.516)
ln(firm size 99)	0.025*** (0.005)		0.001 (0.005)	0.025*** (0.005)		0.001 (0.005)
ln(labprod 99)	-0.015 (0.011)		-0.063*** (0.012)	-0.014 (0.011)		-0.063*** (0.012)
ln(skill intensity)	0.037*** (0.012)		0.042*** (0.012)	0.037*** (0.012)		0.042*** (0.012)
Exports 99 dummy	-0.029** (0.014)		-0.012 (0.015)	-0.027* (0.014)		-0.010 (0.015)
Imports 99 dummy	0.000 (0.014)		-0.022 (0.015)	0.002 (0.014)		-0.021 (0.015)
ln(Imp. comp)	-0.003 (0.009)		-0.003 (0.008)	-0.002 (0.009)		-0.002 (0.009)
ln(Swe control)	-0.002 (0.023)		-0.001 (0.022)	-0.001 (0.022)		-0.001 (0.022)
No. of obs.	4755	4855	4755	4755	4855	4755

The dependent variable is  $\Delta y_{ij1} - \Delta y_{ij0}$  with  $\Delta y_{ijt}$  defined as in (4) with  $Y_{ijt}$  representing employment in terms of man hours. \*\*\* significant at the .01 level, \*\* significant at the .05 level, \* significant at the .1 level. Standard errors in parenthesis.

**Selection:** There is one selection issue that could potentially bias our results. Our econometric strategy precludes using data on firms entering or exiting the sample, so firms which failed during the sample period are dropped. Balancing the panel is not a random process and firms staying in business may respond differently to shocks than those who are driven out of business. This factor will tend to bias our results in the direction of not finding any effects of the RER shock, since the failing firms may be expected to have responded more strongly to the RER shock than the continuing firms rather than the other way around.

The standard technique employed in these circumstances, due to Heckman (1979), involves two steps.<sup>17</sup> First, a model to explain the probability of

<sup>17</sup>Wooldridge (2001) describes selection models for attrition problems in panel data.

a firm being in the continuous sample is estimated using a reduced-form probit model. Second, a correction term is constructed using the inverse Mills ratio from the probit and used as an additional regressor in the estimation of (6) to correct for selection.

The dependent variable in the first stage  $s_i$  is a dummy variable taking the value 1 if the firm is present from the beginning to the end of the sample. The dependent variable is set to 0 if the firm was present in 1999 but exited in 2004 or earlier.

The probability of exit will generally depend on the same characteristics that affect the RER response. However, if the set of explanatory variables are identical in both stages, the model is identified based on the functional form alone, which can lead to multicollinearity problems. Hence, we choose a somewhat different set of variables in the first stage. Specifically, we choose variables which are significant in a stand-alone probit estimation. These are: number of employees and labor productivity together with export and import status (dummies). All variables in the selection equation refer to values in 1999.

Formally, we model the exit decision as

$$s_i = 1 [w_i'\delta + \omega_i > 0]$$

where  $1[\ ]$  is an indicator function and  $w_i$  is a vector of covariates. As is well known, assuming joint normality of errors  $v_i$  and  $\omega_i$ , the errors in the second step  $v_i$  now has expectation

$$\begin{aligned} E[v_i | s_i = 1] &= E[v_i | \omega_i > -w_i'\delta] \\ &= \sigma_{12} E[\omega_i | \omega_i > -w_i'\delta] = \sigma_{12} \lambda(w_i\delta) \end{aligned}$$

where  $\sigma_{12}$  is the covariance between  $\omega_i$  and  $v_i$  and  $\lambda(\ )$  is the inverse Mills ratio. Maximum likelihood estimates are reported in columns (1c) and (2c) of Table 3.<sup>18</sup> The estimated coefficients are almost identical to the corresponding non-selection estimations.

**Economic significance:** Our empirical results point to a clear link between the real appreciation and the fall in manufacturing employment. The estimated coefficient on net exposure indicates that employment would fall by 0.9 – 1.1 per cent for a one per cent real appreciation for a firm with a net exposure equal to one. As the weighted mean net exposure of the manufacturing sector was .11 at the beginning of the period (i.e. in 1999), we infer that the 14 per cent real appreciation between 2000 and 2004 resulted in a 1.4 – 1.7 per cent reduction in employment. This implies that around one

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<sup>18</sup>MLE is more efficient than the 2-step procedure under joint normality of the errors.

seventh of the total decline in manufacturing employment over this period can be attributed to the real appreciation.

## 4.2 Firm exit

The adverse impact of a RER shock may be reflected through reduced employment, and most severely lead to the close-down of firms. In order to address the impact of the real appreciation on exit, we look at whether firms exited sometime during the period 2001-2004. Specifically, we estimate the following simple logit model:

$$\Pr[Exit_i = 1|x_i, \beta] = \frac{\exp[\alpha + \beta\Lambda_{ij} + \phi\mathbf{x}_{ij99}]}{1 + \exp[\alpha + \beta\Lambda_{ij} + \phi\mathbf{x}_{ij99}]}$$

where  $Exit_i = 1$  if the firm is present in 2001 but not in 2004,  $\alpha$  is an intercept term, and  $\mathbf{x}_{ij99}$  is the same vector of controls used in the analysis above.

**Table 4: Firm level: Probability of exit, 2001-2004**

	Logit (a)	Logit (b)
Net exposure $\Lambda$	0.221 (0.149)	
E exposure $\lambda$		0.103 (0.107)
I exposure $\tilde{\lambda}$		-0.046 (0.151)
ln(firm size 99)	-0.185*** (0.021)	-0.183*** (0.021)
ln(labprod 99)	-0.427*** (0.042)	-0.428*** (0.043)
ln(skill intensity)	0.061 (0.054)	0.064 (0.054)
Exports 99 Dummy	0.133** (0.063)	0.129* (0.029)
Imports 99 Dummy	-0.180*** (0.059)	-0.189*** (0.059)
ln(Imp. comp)	-0.010 (0.038)	-0.010 (0.038)
No. of obs.	7734	7734

\*\*\* significant at the .01 level, \*\* significant at the .05 level, \* significant at the .1 level. Standard errors in parenthesis.

As is evident from Table 4, size and productivity are highly significant predictors of exit; the larger and more productive the firm, the lower the probability of closing down. Perhaps surprisingly, we do not find that the probability of exit in this period was related to currency exposure. However, whether firms exported and/or imported at all are found to matter; exporters were more likely to exit, while firms importing intermediates were less likely

to do so. In this sense, there is some evidence of the initial trade pattern of the firm being important for its ability to survive. But conditional on a firm being an exporter, the extent to which its sales consist of exports has no additional effect on the probability of exit. Similarly, conditional on a firm being an importer of intermediates, the extent to which its costs consist of such imports has no additional effect on the probability of exit.

### 4.3 Productivity

Next we turn to productivity, measured as labor productivity or TFP using the Olley-Pakes (1996) methodology. As before, we start by looking at the industry level, where our results mirror the ones for employment. The results presented in Table 5 show that industries with higher net exposure had no different (change in) productivity growth than other industries. However, industries that at the beginning of the period (1999) had the highest productivity level also experienced the greatest improvement in labor productivity. Our findings appear to be rather robust, in the sense that taking out all or some of the other controls does not change this result.

**Table 5: Industry level: Productivity growth 9900 vs. 0204**

	OLS LP	OLS TFP
Net exposure $\Lambda$	-0.565 (2.202)	1.324 (1.769)
ln(firm size 99)	-0.012 (0.033)	-0.000 (0.026)
ln(labprod 99)	-0.344* (0.193)	-0.145 (0.155)
ln(skill intensity)	0.237*** (0.080)	0.087 (0.065)
ln(exports 99)	0.007 (0.066)	0.072 (0.053)
ln(imports 99)	0.010 (0.020)	0.001 (0.016)
ln(imp. comp)	0.007 (0.030)	0.015 (0.024)
ln(Swe control)	-0.519 (0.619)	-0.244 (0.497)
No. of obs.	202	202

Note: The dependent variable is  $\Delta y_{j1} - \Delta y_{j0}$  with  $\Delta y_{jt} = \ln Y_{jt} - \ln Y_{jt-1}$  with  $Y_{jt}$  representing labor productivity (LP) and Total factor productivity (TFP). \*\*\* significant at the .01 level, \*\* significant at the .05 level, \* significant at the .1 level. Standard errors in parenthesis.

The results reported in Table 5 suggest that it is not possible to relate the variation in productivity growth across industries to industry-level differences

in currency exposure.<sup>19</sup> They also suggest that the RER shock did not induce any productivity gains via market-share shifts, or allocation changes, favoring high-productivity plants. An implication of models with firm heterogeneity of the Melitz (2003) type is that increased competition in the market leads firms in the lower end of the productivity distribution to exit, creating scope for higher-productivity firms to expand. This change in the composition of firms leads to an increase in average productivity at the industry level. A similar mechanism could be at work here – leading to stronger composition effects in highly exposed sectors than in less exposed sectors. However, our results do not support such a hypothesis. It remains to be seen, however, if the RER shock was associated with within-firm productivity gains.

Moving down to the level of the firm again, a different picture emerges. Controlling for size and skill intensity, Table 6 shows that firms with a positive net exposure on average have a higher increase in labor productivity growth. The increase in productivity growth is most pronounced among small firms.

**Table 6: Firm level; labor productivity, skill intensity, size and net exposure**

Firm size	Exposed	Skill-intensity	No of firms	$\Delta y_{i0}$	$\Delta y_{i1}$	$\Delta y_{i1} - \Delta y_{i0}$
Small	No	High	2069	1.6	8.8	7.2
Small	Yes	High	392	-2.3	18.1	20.4
Small	No	Low	965	-0.8	8.1	8.9
Small	Yes	Low	124	-10.5	15.2	25.7
Large	No	High	617	0.3	5.3	5.1
Large	Yes	High	356	12.4	17.8	5.5
Large	No	Low	251	4.2	8.4	4.2
Large	Yes	Low	81	-1.4	8.9	10.3

Note:  $\Delta y_{i0}$  : growth 1999-2000,  $\Delta y_{i1}$  : growth 2002-2004; Firm size: Small:  $\leq 20$  employees, Large:  $> 20$  employees; Exposed: No:  $\Lambda < 0$ , Yes:  $\Lambda > 0$ ; Skill intensity: Low:  $< .18$ , High:  $\geq .18$

The econometric analysis confirms these descriptives. The real appreciation had a significant impact on firms' productivity, see Table 7. The results from the selection model, see columns (7b) and (7d), are nearly identical to OLS. Our results suggest that the higher net exposure, the greater the increase in within-firm productivity growth. A corresponding table using gross exposure instead of net exposure is presented in the appendix (see Table A3).

<sup>19</sup>As is evident from Table A2 in the appendix, industries differ widely in terms of labor productivity and TFP.

This reveals that the coefficients for export and import exposure have the expected signs and that they are highly significant.

**Table 7: Firm level: Labor productivity and TFP growth 99-00 vs. 02-04**

	OLS LP	ML-HS LP	OLS TFP	ML-HS TFP
Net exposure $\Lambda$	1.172** (0.458)	1.172*** (0.458)	1.309*** (0.409)	1.309*** (0.409)
ln(firm size 99)	-0.014*** (0.005)	-0.014*** (0.006)	-0.003 (0.005)	-0.004 (0.005)
ln(labprod 99)	0.228*** (0.012)	0.226*** (0.012)	0.180*** (0.010)	0.178*** (0.011)
ln(skill intensity)	-0.027** (0.013)	-0.026** (0.013)	-0.010 (0.011)	-0.010 (0.011)
Exports 99 Dummy	-0.010 (0.015)	-0.010 (0.015)	-0.016 (0.013)	-0.016 (0.013)
Imports 99 Dummy	0.001 (0.014)	0.001 (0.015)	-0.013 (0.013)	-0.014 (0.013)
ln(Swe control)	0.020 (0.024)	0.020 (0.024)	0.020 (0.021)	0.020 (0.021)
ln(imp. comp)	-0.015 (0.009)	-0.015 (0.009)	0.000 (0.008)	0.001 (0.008)
No. of obs.	4755	4755	4755	4755

Note: The dependent variable is  $\Delta y_{ij1} - \Delta y_{ij0}$  with  $\Delta y_{ijt} = \ln Y_{ijt} - \ln Y_{ijt-1}$  with  $Y_{ijt}$  representing labor productivity (LP) and Total factor productivity (TFP). \*\*\* significant at the .01 level, \*\* significant at the .05 level, \* significant at the .1 level. Standard errors in parenthesis.

**Economic significance:** The manufacturing sector as a whole experienced an 18 percent increase in labor productivity and a 10 percent rise in TFP between 2000 and 2004. Our analysis indicates that the positive development in productivity was driven by restructuring and productivity improvements within each firm – and not by reallocation of resources from less productive towards more productive firms. The firms most exposed to the RER shock gave the most significant contribution to the increase in productivity growth. The greater a firm’s exposure the greater its increase in productivity growth. As discussed above, these were also the firms having to take the largest cut in employment, in terms of hours worked. Based on the estimated coefficients, we infer that the RER shock caused a 2 per cent increase in labor productivity and TFP, or approximately one fifth of the manufacturing TFP growth during the period. There is huge variation across industries in export and import exposure. For example, in the most exposed sectors like paper (Nace 21), metals (Nace 27) and vehicles (Nace 34), approximately a 6 per cent increase in labor productivity, and 7 per cent increase in TFP, can be ascribed to the RER shock. Given that these sectors employed about 12 per cent of the manufacturing labor force in 1999, we

infer that about 2/5 of the total RER-induced increase in productivity was due to productivity growth in these sectors alone.

The increase in productivity in exposed firms suggests that the increased competitive pressure led to rationalization in these firms. This is consistent with the hypothesis of X-inefficiency as well as recent theoretical results linking productivity increases in multi-product firms to a stronger focus on products with core competencies (Bernard, Redding and Schott, 2006).

#### 4.4 Firms' internationalization strategy

Finally we address the question of whether the RER shock affected firms' internationalization strategy. We look at two key variables: FDI (measured by foreign affiliate sales) and offshoring (measured by share of imports in intermediates). Our econometric strategy precludes using data on firms entering or exiting into offshoring and/or FDI, so in specifications where the import share is required to be positive, the sample is reduced to about 1.600 observations. When affiliate sales is the dependent variable, the sample is further reduced to 41 observations.

**Table 8: Firm level: Offshoring and FDI, 99-00 vs. 02-04**

	OLS FDI	OLS FDI	OLS Impshare	OLS Impshare
Net exposure $\Lambda$	10.147*** (3.528)		5.695*** (2.001)	
Export exposure $\lambda$		7.245* (4.067)		5.564*** (2.001)
Import exposure $\tilde{\lambda}$		3.967 (10.823)		-7.813*** (2.353)
ln(firm size 99)	-0.016 (0.084)	0.056 (0.098)	-0.084*** (0.028)	-0.095*** (0.029)
ln(labprod 99)	-0.042 (0.204)	0.014 (0.206)	-0.133** (0.064)	-0.139** (0.064)
ln(skill intensity)	-0.028 (0.201)	-0.039 (0.198)	0.058 (0.067)	0.060 (0.067)
ln(exports 99)	-0.106 (0.071)	-0.081 (0.072)	-0.073*** (0.017)	-0.072*** (0.017)
ln(imports 99)	0.107 (0.055)	0.040 (0.073)	0.161*** (0.019)	0.172*** (0.019)
ln(Swe control)	-0.033 (0.316)	-0.008 (0.312)	-0.113 (0.095)	-0.107 (0.095)
ln(imp. comp)	0.054 (0.179)	0.019 (0.178)	-0.151*** (.051)	-0.139*** (.051)
No. of obs.	41	41	1571	1571

Note: The dependent variable is  $\Delta y_{ij1} - \Delta y_{ij0}$  with  $\Delta y_{ijt} = \ln Y_{ijt} - \ln Y_{ijt-1}$  with  $Y_{ijt}$  representing FDI (measured by affiliates sales) and Offshoring (measured by share of imports in intermediates, *Impshare*). \*\*\* significant at the .01 level, \*\* significant at the .05 level, \* significant at the .1 level. Standard errors in parenthesis.

The changes in firms' internationalization strategies are mainly in line with what we would expect, see Table 8. The firms that suffered the most from the real appreciation increased their natural hedge by increasing production activities abroad (FDI) and by outsourcing a greater share of their intermediates from abroad. However, the impact of import status *ex ante* requires some careful consideration, as we find that the *level* of imports has a positive effect on offshoring behavior. One interpretation of this result is that the level of imports proxies unobserved measures of firm efficiency such as managerial ability, which may be positively correlated with increasing outsourcing.

Turning to the results using gross exposure, we see that firms experiencing a benign effect from the RER shock due to a high share of imported intermediates (and low export share) actually decreased their offshoring. However, for most Norwegian industries import and export shares are positively correlated, so this effect is quantitatively small.

**Economic significance:** The manufacturing sector as a whole experienced a 2 percentage points increase in the import share from 1999 to 2004 (from 19 per cent to 21 per cent). Based on the estimated coefficients for the impact of exposure on international outsourcing, we infer that the RER shock increased the import share with about 9 per cent. This is equivalent to  $1\frac{1}{2}$  percentage points increase in the import share.

## 5 Conclusions

Despite there being numerous studies on the economic effects of real exchange rate shocks, there is very little evidence of adjustment to RER shocks on the firm level. Firms within the same industry are found to differ significantly in size, productivity and trade exposure. In order to understand how the economy adjusts to real exchange rate shocks it is, thus, necessary to study the impact at a disaggregated level.

In this paper, we treat the sharp appreciation of the Norwegian Krone in the early 2000s as a natural experiment in order to assess the adjustment to real exchange rate shocks. We exploit the fact that firms had very heterogeneous exposure to foreign markets before the shock. Specifically, the most exposed were *ex ante* more likely to be affected by the shock. We examine growth performance for these firms before and after the shock and compare them to a comparison group of firms which were *ex ante* less exposed.

Several strong conclusions emerge from the analysis. First, the RER shock was associated with substantial employment losses. One seventh of the total decline in manufacturing employment over the period under study

can be attributed to the real appreciation shock. Second, the shock lead to productivity gains at the firm level, indicating that the most exposed firms were able to improve efficiency in a period of tougher foreign market conditions. Somewhat surprisingly, we do not find evidence for market reallocation effects. Third, firms increased their natural hedge by outsourcing a greater share of their inputs from abroad. For the manufacturing industry as a whole, the real appreciation increased outsourcing, as measured by the import share, by about  $1\frac{1}{2}$  percentage point.

## References

- [1] Bernard, A. B., J. B. Jensen, S. J. Redding and P. K. Schott, 2007, "Firms in international trade", *Journal of Economic Perspectives* 21, 105-130.
- [2] Bernard, A. B., S. J. Redding and P. K. Schott, 2006, "Multi-Product Firms and Trade Liberalization", NBER Working Paper No. 12782.
- [3] Burgess, S. and M. Knetter, 1998, "An International Comparison of Employment Adjustment to Exchange Rate Fluctuations", *Review of International Economics* 6, 151-163.
- [4] Branson, W. and J. Love, 1988, "US manufacturing and the real exchange rate", in Marston, R. C. (ed.), *Misalignment of exchange rates: Effects on trade and industry*, National Bureau of Economic Research Project Report Series, University of Chicago Press, Chicago and London.
- [5] Campa, J. and L. Goldberg, 1995, "Investment in manufacturing, exchange rates and external exposure", *Journal of International Economics* 38, 297-320.
- [6] Campa, J. and L. Goldberg, 2001, "Employment versus wage adjustment and the US dollar", *Review of Economics and Statistics* 83, 477-489
- [7] Colantone, I., 2006, "Trade Openness, Real Exchange Rates and Job Reallocation: Evidence from Belgium", mimeo, LICOS, Katholiek University, Leuven.
- [8] Fung, L., 2008, "Large Real Exchange Rate Movements, Firm Dynamics, and Productivity Growth", *Canadian Journal of Economics* 41, forthcoming

- [9] Fung, L. and Liu, J.-T., 2008, "The impact of real exchange rate movements on firm performance: a case study of Taiwanese manufacturing firms", *Japan and the World Economy*, forthcoming
- [10] Goldberg, L., J. Tracy, S. R. Aaronson, 1999, "Exchange Rates and Employment Instability: Evidence from Matched CPS Data", *American Economic Review* 89, 204-210.
- [11] Gourinchas, P.-O., 1998, "Exchange rates and jobs: What do we learn from gross flows?", in B. Bernanke and J. Rotemberg (eds), *NBER Macroeconomics Annual*, MIT Press.
- [12] Gourinchas, P.-O., 1999, "Exchange rates do matter: French job reallocation and exchange rate turbulence, 1984-1992", *European Economic Review* 43, 1279-1316
- [13] Haltiwanger, J., A. Kugler, M. Kugler, A. Micco, and C. Pagès, 2004, "Effects of Tariffs and Real Exchange Rates on Job Reallocation", Evidence from Latin America", *Journal of Policy Reform* 7, n.º 4, December
- [14] Heckman, J. J., 1979, "Sample Selection Bias as a Specification Error." *Econometrica* 47, 153-61
- [15] Klein, M. W., S. Schuh, and R. T. Triest, 2003, "Job creation, job destruction, and the real exchange rate", *Journal of International Economics* 59, 239-265
- [16] Melitz, M., 2003, "The impact of trade on intra-industry reallocations and aggregate industry productivity", *Economica* 71, 1695-1725
- [17] Nucci, F. and A. F. Pozzolo, 2004, "The Effects of Exchange Rate Fluctuations on Employment: An Analysis with Firm-Level Panel Data", mimeo
- [18] OECD, 2004, *OECD Economic surveys: Norway 2004*
- [19] OECD, 2008, *OECD Main Economic Indicators: Comparative subject tables Vol 2008 release 04*
- [20] Olley, G. S. & Pakes, A., 1996, "The Dynamics of Productivity in the Telecommunications Equipment Industry," *Econometrica*, Econometric Society, vol. 64(6), pages 1263-97
- [21] Raknerud, A., D. Rønningen and T. Skjerpen, 2004, "Documentation of the capital database", *Statistics Norway Documents 2004/16*

- [22] Swenson, D., 2004, "Overseas Assembly and Country Sourcing Choices", *Journal of International Economics*, 66, 107-130
- [23] Trefler, D., 2004, "The Long and Short of the Canada-U.S. Free Trade Agreement", *American Economic Review* 94, 870-895.
- [24] Wooldridge, J. M., 2001, "Econometric Analysis of Cross Section and Panel Data", The MIT Press

# A Appendix

## A.1 Variables and definitions

*Exports* represent the sum of a firm's export value across destinations and are deflated using 2 digit SITC level deflators<sup>20</sup>.

*Imports* represent the sum of a firm's import value of intermediates across sourcing countries and are deflated using 2 digit SITC level deflators.

*Export share* is defined as export value relative to total revenue, measured in current prices.

*Import share* is defined as import value relative to total operating costs.

*Net currency exposure* = *Export share* - *Import share*.

*Import competition* in sector 2 digit NACE sector  $j$  is defined as total import value in  $j$  relative to total absorption in  $j$  in our base year. Absorption is calculated as (production value $_j$ ) - (export value $_j$ ) + (import value $_j$ ). All variables are gathered from Norwegian input-output matrices<sup>21</sup>.

*Affiliate sales* are measured as total revenue of the affiliate multiplied by the parent's ownership share in the affiliate. *Affiliate sales share* is defined as affiliate sales relative to operating revenue.

*Employment* and *firm size* refer to number of employed persons in the firm.

*Hours* refers to the number of man hours per firm per year.

*Earnings* refer to earnings per employee, measured as total wage costs per employee.

*Labor productivity* is measured as deflated value added relative to man hours. The deflator is the commodity price index for the industrial sector at the 2 digit NACE level<sup>22</sup>.

*TFP* is estimated using a value added production function  $y_{it} = \beta_0 + \beta_k k_{it} + \beta_l l_{it} + \omega_{it} + \eta_{it}$ , where  $y_{it}$  is deflated value added,  $k_{it}$  is deflated capital,  $l_{it}$  is employment (all in logs).  $\omega_{it}$  is unobserved productivity and  $\eta_{it}$  is either measurement error or a shock to productivity which is not forecastable during the period in which labor can be adjusted. We control for endogeneity of input demands and self-selection induced by exit behavior using Olley-Pakes (1996) techniques.

*Capital intensity* is measured as annualized user cost of capital (including leased capital) relative to hours worked. The cost of capital is calculated as  $R_{it}^k = (r + \delta_k)K_{it}^k$ , where  $K_{it}^k$  is the real net capital stock of type  $k$ , for firm  $i$

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<sup>20</sup>[http://www.ssb.no/english/subjects/08/03/40/uhvp\\_en](http://www.ssb.no/english/subjects/08/03/40/uhvp_en)

<sup>21</sup>[http://ssb.no/nr\\_en/input-output.html](http://ssb.no/nr_en/input-output.html)

<sup>22</sup>[http://www.ssb.no/english/subjects/08/02/20/ppi\\_en](http://www.ssb.no/english/subjects/08/02/20/ppi_en)

at time  $t$ ,  $k$  is either buildings and land or ( $b$ ) or other tangible fixed assets<sup>23</sup> ( $o$ ),  $r$  is the real rate of return, which we calculated from the average real return on 10-year government bonds in the period 1996-2004 (4.2 per cent), and  $k$  is the median depreciation rates obtained from accounts statistics. The total cost of capital is  $R_{it}^b + R_{it}^o$ .

*Relative hourly wage costs* for workers in manufacturing is a trade weighted measure of relative wages measured in a common currency. The index is produced and updated annually by the Technical Calculating Committee on Income Settlements (Teknisk Beregningsutvalg, TBU)<sup>24</sup>. We use this measure proxying for  $\Delta P_1 - \Delta P_0$  in the econometric analysis. Note that our identification strategy is completely invariant to the choice of RER. The RER measure will, however, affect the magnitude of the estimated  $\beta$ .

*Skill intensity* is defined as the number of high skill employees relative to total employment in each NACE 2 digit sector in year 2000.

Swedish *employment* refers to number of employed persons in a given NACE 3 digit sector. The data is gathered from Statistics Sweden webpages<sup>25</sup> and then manually linked to the Norwegian dataset.

Further details on the variables in the database are provided by Raknerud, Rønningen and Skjerpen (2004)<sup>26</sup>.

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<sup>23</sup>The latter group consists of machinery, equipment, vehicles, movables, furniture, tools, etc.

<sup>24</sup><http://www.regjeringen.no/nb/dep/aid/tema/Inntektspolitikk/rapporter-fra-tbu.html>

<sup>25</sup><http://www.ssd.scb.se/databaser/makro/Produkt.asp?produktid=Nv0109>

<sup>26</sup>[http://www.ssb.no/english/subjects/10/90/doc\\_200416\\_en/doc\\_200416\\_en.pdf](http://www.ssb.no/english/subjects/10/90/doc_200416_en/doc_200416_en.pdf)

## A.2 Tables

Table A1: Currency exposure and employment growth, industry level

Nace				Employment			Hours worked		
	$\lambda$	$\tilde{\lambda}$	$\Lambda$	$\Delta_0$	$\Delta_1$	$\Delta_1 - \Delta_0$	$\Delta_0$	$\Delta_1$	$\Delta_1 - \Delta_0$
15	0.10	0.13	-0.03	-8.4	-1.1	7.3	-8.9	-5.3	3.6
17	0.24	0.26	-0.02	-3.5	-5.6	-2.1	-0.2	-9.3	-9.1
18	0.14	0.22	-0.08	-13.4	-4.8	8.6	-10.2	-10.6	-0.4
19	0.10	0.17	-0.07	12.0	-0.2	-12.2	8.6	0.3	-8.4
20	0.13	0.13	0.00	5.0	-2.1	-7.2	5.5	-2.3	-7.7
21	0.63	0.16	0.46	-12.9	-3.3	9.6	-8.5	-8.4	0.1
22	0.01	0.04	-0.03	-5.0	-4.2	0.8	-0.5	-3.2	-2.7
24	0.47	0.21	0.26	-14.5	-1.2	13.3	-12.2	-4.0	8.2
25	0.26	0.27	-0.01	-4.2	-2.6	1.7	-5.7	-5.0	0.7
26	0.10	0.14	-0.04	0.0	-2.1	-2.1	1.8	-6.0	-7.8
27	0.66	0.31	0.35	-2.6	-2.3	0.3	5.3	-7.7	-13.0
28	0.16	0.11	0.04	-4.3	-1.6	2.7	-5.0	-2.5	2.6
29	0.25	0.19	0.06	-4.8	-5.0	-0.3	-5.6	-6.7	-1.2
30	0.17	0.38	-0.20	31.6	-8.1	-39.6	231.5	-14.8	-246.3
31	0.31	0.19	0.11	12.1	-2.1	-14.2	19.3	0.9	-18.4
32	0.18	0.11	0.07	-22.3	-3.1	19.1	-18.9	-4.1	14.8
33	0.50	0.22	0.29	-11.0	1.8	12.8	-10.1	0.7	10.9
34	0.56	0.24	0.32	-4.4	-7.7	-3.3	1.5	-9.5	-11.0
35	0.12	0.11	0.01	-1.1	-4.2	-3.1	-2.3	-7.1	-4.8
36	0.20	0.19	0.00	-2.4	-6.2	-3.8	-1.0	-7.2	-6.1
37	0.12	0.07	0.05	18.3	7.1	-11.2	16.9	-1.0	-17.9

$\lambda$  is export exposure,  $\tilde{\lambda}$  import exposure and  $\Lambda$  net exposure.  $\Delta_i$  refers to the percentage change in interval  $i$ . Exposure is calculated in the base year (1999).

Table A2: Currency exposure and productivity growth, industry level

Nace	$\Lambda$	Labor productivity			TFP		
		$\Delta_0$	$\Delta_1$	$\Delta_1 - \Delta_0$	$\Delta_0$	$\Delta_1$	$\Delta_1 - \Delta_0$
15	-0.03	6.0	10.2	4.2	4.1	7.8	3.7
17	-0.02	-0.1	6.1	6.2	0.2	2.9	2.7
18	-0.08	12.8	25.8	12.9	14.8	18.5	3.8
19	-0.07	6.3	2.0	-4.3	5.7	-6.4	-12.1
20	0.00	7.7	5.9	-1.8	7.3	3.7	-3.6
21	0.46	22.2	14.6	-7.6	16.0	11.9	-4.1
22	-0.03	-3.1	6.9	1.0	-2.2	5.7	7.9
24	0.26	-2.9	4.3	7.2	-7.5	2.2	9.7
25	-0.01	-1.8	6.4	8.3	-3.9	3.8	7.7
26	-0.04	4.2	10.4	6.2	2.4	8.1	5.8
27	0.35	32.1	28.5	-3.6	34.3	20.0	-14.4
28	0.04	-11.5	-0.8	10.8	-11.8	-1.5	10.4
29	0.06	-1.8	1.2	3.1	-3.9	-1.2	2.7
30	-0.20	-51.9	51.9	103.7	-27.8	59.5	87.3
31	0.11	-0.8	10.4	11.2	2.0	10.2	8.2
32	0.07	14.7	13.8	-0.9	16.2	12.8	-3.4
33	0.29	-15.8	8.9	24.7	-20.3	6.9	27.1
34	0.32	-1.3	17.2	18.5	0.5	14.8	14.3
35	0.01	-8.7	4.8	13.5	-10.3	2.8	13.1
36	0.00	3.1	11.7	8.6	-0.6	9.6	10.2
37	0.05	20.8	20.1	-0.7	19.6	16.2	-3.4

$\Delta_i$  refers to the percentage change in interval  $i$ . Exposure is calculated in the base year (1999).

**Table A3: Firm level: Labor productivity and TFP growth 99-00 vs. 02-04. Gross exposure.**

	OLS LP	ML-HS LP	OLS TFP	ML-HS TFP
E exposure $\lambda$	1.068** (0.467)	1.069** (0.466)	1.180*** (0.416)	1.180*** (0.416)
I exposure $\tilde{\lambda}$	-1.536*** (0.553)	-1.535*** (0.552)	-1.758*** (0.493)	-1.757*** (0.492)
ln(firm size 99)	-0.014*** (0.005)	-0.014*** (0.006)	-0.003 (0.005)	-0.003 (0.005)
ln(labprod 99)	0.228*** (0.012)	0.227*** (0.013)	0.181*** (0.010)	0.179*** (0.012)
ln(skill intensity)	-0.027** (0.042)	-0.027** (0.013)	-0.011 (0.011)	-0.011 (0.011)
Exports 99 Dummy	-0.008 (0.015)	-0.007 (0.015)	-0.013 (0.013)	-0.012 (0.013)
Imports 99 Dummy	0.003 (0.014)	0.002 (0.015)	-0.011 (0.013)	-0.012 (0.013)
ln(Swe control)	0.022 (0.024)	0.022 (0.024)	0.022 (0.021)	0.022 (0.021)
ln(imp. comp)	-0.014 (0.009)	-0.014 (0.009)	0.001 (0.008)	0.001 (0.008)
No. of obs.	4755	4755	4755	4755

Note: The dependent variable is  $\Delta y_{ij1} - \Delta y_{ij0}$  with  $\Delta y_{ijt} = \ln Y_{ijt} - \ln Y_{ijt-1}$  with  $Y_{ijt}$  representing labor productivity (LP) and Total factor productivity (TFP). \*\*\* significant at the .01 level, \*\* significant at the .05 level, \* significant at the .1 level. Standard errors in parenthesis.