Manufacturing Restructuring and the Role of Real Exchange Rate Shocks: A Firm-Level Analysis

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Abstract

A shortcoming of the empirical literature on the impact of real exchange rate (RER) fluctuations on job reallocation and net employment is a lack of detailed information on trade exposure, and thus on exposure to movements in the exchange rate. Recent contributions to the trade literature have shown that firms' exposure to trade varies significantly also at the industry level. In this paper we use detailed Norwegian firm-level data on export and import exposure 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 the response with respect to employment, productivity, and offshoring. Using a difference-in-difference specification, we find that the relative cost shock that hit the Norwegian economy led to a decline in more exposed firms' employment. But the RER shock also appears to have contributed to a process of manufacturing restructuring involving offshoring of intermediate input production as well as final goods production that boosted firms' productivity.

JEL Classification: F14, F16, F4

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1 Introduction

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 bursted. As a consequence the Norwegian Krone appreciated sharply. Prior to year 2000 the real exchange rate had been rather stable, but from year 2000 to 2002 the real exchange rate rose by around 17 per cent, see Figure 1.

By the end of 2004 around 32 000 manufacturing jobs had been eliminated, implying that the manufacturing labor force 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 of Norway in 2004 that "the monetary policy stayed too tight for too long".[1]

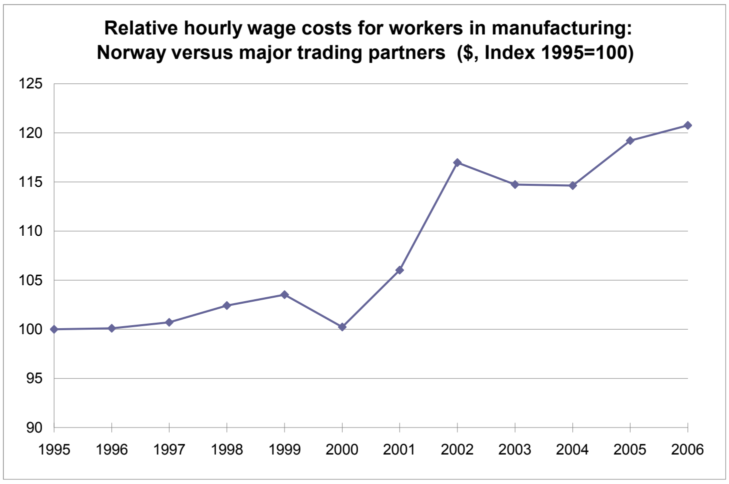

Figure 1: The Norwegian RER-shock 2000-2002

The unanticipated real appreciation of the Norwegian Krone 2000-2002 lends itself as a natural experiment to study the consequences of a real exchange rate (RER) shock for manufacturing restructuring. One of the key

[1] See OECD (2004).

questions we address in this paper is how a real appreciation affects employment in the manufacturing sector. Almost all western countries have experienced a steady decline in manufacturing employment over the last decades. The contribution of the RER shock in Norway to this development is, thus, not clear. We investigate what part of the decline in Norwegian manufacturing employment can be related to the RER shock.

But our interest in the impact of RER shock goes beyond the effect on net employment. We also seek to understand the dynamics and adjustments underlying the aggregate effects. Therefore, we do not limit the analysis to the impact on employment, but extend it to study the development of productivity as well as firms' internationalization strategies.

From a methodological point of view, the main contribution of the paper is how we are able to account for the fact that changes in real exchange rates 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 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 have benefitted from firm level data on employment, measures of trade exposures have all been calculated based on industry level information. Since firms within an industry are known to differ significantly in terms of exports as well as imports of intermediates, measures of trade exposure calculated at the industry level are likely to be rather inaccurate.

Using a new and extensive micro data set for Norwegian manufacturing firm with detailed information on firms' export as well as imports of intermediates, we are able to calculate precise measures of trade exposure. Because we have firm-level data on export shares as well as shares of imports in intermediates, we are able to take into account the two opposing effects of a real appreciation on firms' profitability; the decrease in revenues related to a decrease in the price of exports and the decrease in costs related to a decrease in the price of imported intermediates. Our disaggregated data set moreover allows us not only to assess the impact of a RER shock on employment, but also to examine the potential impact of the shock on manufacturing restructuring. We study how the RER appreciation affected firms' productivity and their strategies regarding offshoring of intermediate input production as well as final goods production.

The rest of the paper is organized as follows: We provide a brief review of related literature in section 2. In section 3 we lay out our identification strategy, describe the estimation procedure and present the data. In section 4 we present and discuss our empirical results. 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.[2] Therefore it is important to understand how real exchange rate shocks affect the economy. Real depreciations are sometimes welcomed on account of their positive effect on exports and on the relative attractiveness of domestic versus foreign production locations. However, it is unclear whether they really boost output and investment (see e.g. Goldberg, 1993). Moreover, by disproportionately benefitting firms with a low share of imported inputs they may shift resources away from industries with a high import content. Real appreciations are often expected to reduce investment and even lead to firm closure on account of their impact on relative cost levels. At the same time, real appreciations lead to lower prices on imported inputs and may therefore benefit production with a high import content. Furthermore, the positive effect on the distribution of wealth may lead to increased investment in domestic assets (Goldberg, 1993).

A number of papers have examined the impact of real exchange rate changes on employment and job reallocation. Davis et al. (1996) find no systematic relationship between the magnitude of gross job flows and exposure to international trade. However, Klein et al. (2003) find that trend real exchange rates significantly affect job reallocation but not net employment. Cyclical real exchange rates significantly affect net employment through job destruction.

Haltiwanger et al. (2004) find that a reduction in tariffs as well as a real exchange rate appreciation increase job reallocation within sectors. Colantone (2006) finds that a real exchange rate appreciation lowers net job growth through an increase in job destruction, not through a decrease in job creation.

Swenson (2004), studying the cross-country pattern of foreign activities of U.S. multinationals in the 1980s and 1990s, finds that offshore assembly to a destination declines with rising relative costs in that destination. Her results indicate that a 10 percent increase in costs was associated with a decrease

[2] See e.g. Rogoff (1996).

in that country's share of offshore assembly by .8 percentage points (the average share was 5.6 percent). She also found that the response was larger in developing than developed countries and larger in less capital intensive industries than in more capital intensive industries.[3]

3 Estimation Strategy

3.1 Identification

Previous studies focusing on the effect of real exchange rates have based their analyses on cross-industry variation in gross and net job flows and openness to trade. Openness to trade is thus used as a proxy for currency exposure, and while some of these studies use aggregate measures of openness, some have created measures of openness distinguishing between import competition and export intensity.

However, unlike previous studies, we use information on firms' exports as well as their imports of intermediates. This enables us to account for cross-firm rather than cross-industry variation in currency exposure. More importantly, it allows us to construct a measure of currency exposure which takes into account that a RER shock that has an adverse impact on a firm's performance through its exports typically has a benign effect on its performance through its imports of intermediate inputs.

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 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 set at home and abroad, respectively, x_i and x_i^* 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 $R_i = (x_i + P_i x_i^*)\, p_i$, where P_i is the real exchange rate (RER), $P_i \equiv V p_i^*/p_i$. The elasticity of revenue with respect to P_i is

$$\frac{\partial R_i}{\partial P_i}\frac{P_i}{R_i} \equiv \lambda_i = \frac{V p_i^* x_i^*}{R_i}, \tag{1}$$

i.e. it is equal to the firm's export share. An increase in P_i implies a real depreciation. For given output and prices, a one percent real depreciation increases total revenue with λ_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 of domestic and imported inputs, respectively, and v_i and

[3] Gourinchas (1998). Pricing-to-market and exchange rate pass-through (e.g. Goldberg and Knetter).

v_i^* are used quantities of domestic and imported inputs, respectively. We can rewrite costs as $C_i = (v_i + Q_i v_i^*) q_i$, where $Q_i = V q_i^* / q_i$. The elasticity of costs with respect to Q_i is

$$\frac{\partial C_i}{\partial Q_i} \frac{Q_i}{C_i} \equiv \widetilde{\lambda}_i = \frac{V q_i^* v_i^*}{C_i}, \tag{2}$$

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

Suppose $P_i = Q_i$, implying that the RER measured by output prices is equal to the RER measured by factor prices. Then the elasticity of profits (Π_i) – revenues minus costs – with respect to a change in the relative price can be expressed as:

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

Define the *net currency exposure* as the difference between the export share and the share of imported inputs, $\Lambda_i \equiv \lambda_i - \widetilde{\lambda}_i$. A positive Λ_i implies that the effect on profits of a real appreciation (a fall in P_i) is negative, while the effect on profits of a real depreciation (an increase in P_i) is positive.[4]. The greater is Λ_i, the larger the numerical impact of the change in the real exchange rate.

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

It may also be useful to distinguish between exposure related to the export share and exposure related to the share of imported inputs in total costs.

[4]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 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 $\widetilde{\lambda}_i (C_i / R_i) = \lambda_i$, so $\widetilde{\lambda}_i > \lambda_i$ 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.

We refer to the separate exposures on the export and import side as *gross currency exposure*.

With this approach, we are not able to identify RER effects on firms that neither export nor use imported inputs because their net 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 Norwegian real appreciation was rather general in nature. (*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.[5] Secondly, firms can only hedge against nominal currency shocks, not relative output or factor price movements.

3.2 Econometrics

In order to estimate the response to the RER shock we use a differences-in-differences approach, similar to Trefler (2004) in his study of the response to trade reform. We define the years 1999-2000 as the pre-RER-shock period and the years 2002-2004 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.[6]

We want to analyze the response to the RER shock on the firm- and industry level. Let Δy_{ijt} be the average annual log change in the outcome of interest of firm i,in industry j, in period t, such as employment, productivity and outsourcing. Then,

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

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:

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

[5] See Norges Bank: Penger og Kreditt 1/2005.

[6] 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.

where Δy_{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 Λ_{ij} is net currency exposure and p_t is the log of the RER.[7]. The specification includes a growth fixed effect at the level of the firm, α_{ij}, general business conditions (macro shocks) θ_t, and idiosyncratic industry demand and supply shocks, proxied by changes in Swedish manufacturing employment Δy_{jt}^{SE} (in logs). Differencing (5) across periods yields our baseline difference-in-difference firm-level specification:

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

where $\theta \equiv \theta_1 - \theta_0$. Following Trefler (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, earnings per employee, labor productivity, skill intensity, exports and imported inputs (all in logs).

The estimated θ will pick up the change in Δy_{it} which is due to the business cycle (economy-wide changes). This coefficient will also pick up the impact of the RER shock in sheltered and import-competing sectors. 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 number across all industries and firms. However, variation in Λ_{ij} will enable us to make inference about β. Suppose Δy_{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.

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

$$\Delta y_{j1} - \Delta y_{j0} = \theta + \beta\Lambda_{j}\left(\Delta p_1 - \Delta p_0\right) + \gamma(\Delta y_{j1}^{SE} - \Delta y_{j0}^{SE}) + \phi \mathbf{x}_{j99} + \ v_{j} \quad (7)$$

where $\mathbf{x}_{j99}$ represents the vector of the same controls, now measured as averages across the population of firms in each sector.

3.2.1 The Swedish control

Our growth fixed effect α_{ij} will capture time-invariant heterogeneity in growth rates across industries or firms. However, there may be variation in growth rates which coincides with our measure of net exposure. For example, it may be that some industries experience worsening worldwide business conditions, and that these conditions are correlated with the exposure of the

[7] To calculate net currency exposure we use data for the first year of observation, 1999.

sector. To control for idiosyncratic industry shocks – applying worldwide – we use Swedish manufacturing employment data represented by y_{jt}^{SE}. y_{jt}^{SE} will control for underlying worldwide changes in supply and demand, changes in pricing-to-market, and other time-varying industry characteristics. We choose to use Sweden as our control because (i) its' RER was relatively stable during the period under study and (ii) it is Norway's largest trading partner and both labor and product markets are highly integrated.

A possible problem with the Swedish control is that y_{jt}^{SE} may be endogenous. For example, causality can go both ways. Favorable worldwide business conditions may boost Norwegian employment, while Swedish employment is hurt. However, if this was the case, we would expect that Δy_{ij1} and Δy_{j1}^{SE} are negatively correlated. Our data shows that the correlation is positive (.13). Also, we would suspect endogeneity if Δy_{j1}^{SE} and Λ_{ij} are negatively related. That is, if high exposure is correlated with employment growth in Sweden. Again, our data shows that this correlation is virtually zero. However, these correlations are only suggestive, and we therefore choose to proceed with instrumenting $\Delta y_{j1}^{SE} - \Delta y_{j0}^{SE}$. Specifically, we choose Swedish employment in 1998 as our instrument. These levels are unlikely to be correlated with the residuals because the latter are twice differenced. 1998 levels are also likely to be correlated with employment changes. Formally, we assume that y_{jt}^{SE} is weakly exogenous aside from being contemporaneously correlated with the error $\varepsilon_{ijt.}$ Then $E\left[y_{js}^{SE}\varepsilon_{ijt}\right] = 0$ for $s \leq t-1$ implies that $E\left\{y_{js}^{SE}\left[\left(\varepsilon_{ij04} - \varepsilon_{ij02}\right)/2 - \left(\varepsilon_{ij00} - \varepsilon_{ij99}\right)\right]\right\} = E\left[y_{js}^{SE}v_{ij}\right] = 0$ for $s \leq 1998$.

3.2.2 Data

We employ an exhaustive firm-level data set for the Norwegian manufacturing sector which includes detailed information on firms' exports and imports. The data set is based on several data sources. To begin with, we use firm data from Statistics Norway's capital database[8], which is an unbalanced panel of all joint-stock companies spanning the years 1999 to 2004, with approximately 8000 firms per year. 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.

The information about exports and imports is assembled from the customs declarations. These data make up an unbalanced panel of all yearly

[8] Raknerud, Rønningen, Skjerpen (2004), "Documentation of the capital database", mimeo 2004/16, Statistics Norway http://www.ssb.no/english/subjects/10/90/doc_20041.6_en/doc_200416_en.pdf

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 has then been merged with the capital database, based on a firm identifier.

Affiliate sales data is 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.[9] 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.[10] Similarly, the FDI data has then been merged with the capital database, based on a firm identifier.

Our econometric strategy precludes using data on firms entering or exiting the sample, so firms which failed during the sample period are dropped, generating a balanced panel of about 4.800 firm observations. In specifications where both exports and imports are required to be positive, the sample is further reduced to about 1.700 observations. In logit/probit analyses of the probability of firm exit the number of observations is identical to above, plus the number of firms which failed by 2004. In specifications where the affiliate sales variable is required to be positive, the data set collapses to about 50 observations.

In our sector-level analysis, we have aggregated all observations, including firms which failed in the sample period. Labor productivity, TFP, net and gross currency exposure are calculated as weighted means, using firm output as weights.

The descriptive statistics are based on the balanced panel comprising 4.800 firms, except for the aggregate figures of manufacturing employment and productivity.

4 Empirical results

4.1 Employment

We first examine what happened to employment growth and the extent to which this was influenced by the RER shock. At the aggregate level we have already seen that employment growth fell in the manufacturing sector. Moving down to the industry level, 12 out of 21 industries (at nace 2-digit)

[9] The information comes from Skattedirektoratets utenlandsoppgave.

[10] Affiliate sales is here defined as total revenue of the affiliate, adjusted by the parents' ownership share.

faced reduced employment growth after the real appreciation. 63 percent of the firms experienced a decline in employment growth (measured by number of employees as well as hours worked).

Can these declines 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 according to whether their profitability would be hit negatively by a real appreciation (exposed firms) or not (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.

Nevertheless, once we start controlling for other firm characteristics, the picture changes. Table 1 provides an overview of firms' employment growth depending on firms' size, skill intensity and net exposure. Focusing on the change in employment growth, we see that: (*i*) Large firms' employment growth has increased more (or decreased less) than for small firms; (*ii*) Skill intensive firms have higher growth than the unskilled intensive firms, and, most importantly, (*iii*) Employment growth of exposed firms is lower than for non-exposed firms – except for large and skill intensive firms. For the latter group, the opposite is found to be true.

Table 1: Firm characteristics and employment growth

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

Turning to econometrics we first analyze the impact of the RER shock at the industry level (nace 5 digit). Based on the traditional trade theory, we would typically expect a country to be specialized and exporting according to comparative advantage, and thus industries to be hit accordingly differently from a real appreciation. Table A1 in the appendix provides an overview of industries, net exposure and employment growth. In line with what we would expect, industries vary significantly in their exposure. Our empirical results on the impact of the RER shock on employment – measured in terms of employees (*Empl*) and man hours (*hours*) are reported in Table 2. They show that the real appreciation did not have any significant impact on employment growth. In other words, currency exposure did not matter for employment growth.

Nor do we find any systematic variation in employment growth linked to any of the control variables like industry averages of firm size, earnings, labor productivity, skill intensity, exports and imports.

Table 2: Industry level, 2LS (9900 vs. 0204)

	Empl	*Hours*
Net exposure (Λ)	1.831 (2.881)	1.897 (3.041)
ln(firm size 99)	−0.028 (0.042)	−0.017 (0.044)
ln(earnings 99)	−0.348 (0.253)	−0.178 (0.267)
ln(labprod 99)	0.120 (0.105)	0.063 (0.111)
ln(skill intensity)	0.062 (0.086)	0.057 (0.091)
ln(exports 99)	0.027 (0.026)	0.022 (0.027)
ln(imports 99)	0.017 (0.040)	0.015 (0.042)
ln(Swe control)	−0.029 (0.810)	0.322 (0.855)
No. of obs.	202	202
Adj. R^2	0.05	0.03

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 employment in terms of employees (*Empl*) and man hours (*Hours*).

However, recent theoretical and empirical contributions to trade literature stress the importance of firm heterogeneity and significant intra-industry variation in trade exposure, size and productivity.[11] If firms within an industry are heterogeneous in their exposure to trade, we need to move down to the firm level in order to analyze the impact of the RER shock. Table 3 reports the results for the change in employment growth after the shock compared to the period before the shock. It turns out that employment measured in terms of man hours was significantly affected by the real appreciation. The more exposed a firm, the greater the decline in employment growth. We

[11] See Meltiz, 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.

also see that larger, more productive and skill intensive firms experienced a smaller decline in growth, while firms paying relatively higher wages faced a greater decline.

Table 3: Firm level, 2LS (9900 vs. 0204)

	Empl	*Hours*
Net exposure (Λ)	-0.747 (0.568)	-1.566^{**} (0.647)
ln(firm size 99)	0.029^{***} (0.010)	0.035^{***} (0.011)
ln(earnings 99)	-0.200^{***} (0.027)	-0.091^{***} (0.032)
ln(labprod 99)	0.058^{***} (0.022)	0.040^{*} (0.025)
ln(skill intensity)	0.049^{**} (0.021)	0.071^{***} (0.024)
ln(exports 99)	0.001 (0.004)	0.004 (0.005)
ln(imports 99)	-0.006 (0.005)	-0.009 (0.006)
ln(Swe control)	-0.091 (0.287)	0.334 (0.325)
No. of obs.	1710	1710
Adj. R^2	.05	.02

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 employment in terms of employees ($Empl$) and man hours ($Hours$). *** significant at the .01 level, ** significant at the .05 level, * significant at the .1 level. Standard errors in parenthesis.

Our empirical results point to a clear link between the real appreciation and the fall in manufacturing employment. The estimated coefficient indicates that employment (measured by man hours) would fall by 1.6 per cent for a 1 per cent increase in the RER for a firm with a net exposure equal to one. As the weighted mean currency exposure of the manufacturing sector was .11 by the beginning of our time period, we infer that the 14 per cent real appreciation between 2000 and 2004 yielded a 2.46 per cent reduction in employment. This implies that only around one fourth of the total decline in manufacturing employment over this period can be attributed to the real appreciation.

4.2 Firm exits

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 exits, we have chosen to look at firm exits taking place from 2001 to 2004. Specifically, we estimate the following simple logit,

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

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

A bit surprisingly, we do not find that the probability of exit in this period was related to the currency exposure. But size and productivity is found to matter. The larger and more productive the firm, the lower the probability that it exits. Moreover, we observe that a firm's outsourcing strategy also appears to play a role for its survival: the more it outsources of intermediates from abroad, the lower its probability of exit.

Table 4: Firm level: Probability of exit, Logit (2001-2004)

	$\Pr Exit$
Net exposure (Λ)	-0.225 (0.223)
ln(firm size 99)	-0.145^{***} (0.054)
ln(earnings 99)	0.387^{*} (0.199)
ln(labprod 99)	-0.561^{***} (0.146)
ln(skill intensity)	0.097 (0.130)
ln(exports 99)	0.040 (0.029)
ln(imports 99)	0.054^{*} (0.032)
No. of obs.	2172

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

4.3 Productivity

Next we turn to productivity growth, measured as labor productivity or TFP using Olley-Pakes (1996) techniques. Again we start by looking at developments at the industry level. Our findings regarding productivity mirror the ones for employment. While Table A2 in the appendix illustrates that industries differ widely in terms of labor productivity and TFP, the results reported in Table 5 suggest that it is not possible to relate the variation in productivity growth across industries to differences in currencies exposure.

Hence, the real appreciation is not found to have any significant impact on productivity growth measured at the industry level. The industries that by the beginning of the period of observation (1999) had the highest productivity levels and the lowest labor costs were the ones that also experienced the greatest improvement in productivity growth.

Table 5: Industry level, 2LS (9900 vs. 0204)

	LP	TFP
Net exposure (Λ)	-0.565 (2.202)	1.324 (1.769)
ln(firm size 99)	-0.012 (0.033)	-0.000 (0.026)
ln(earnings 99)	-0.344^{*} (0.193)	-0.145 (0.155)
ln(labprod 99)	0.237^{***} (0.080)	0.087 (0.065)
ln(skill intensity)	0.007 (0.066)	0.072 (0.053)
ln(exports 99)	0.010 (0.020)	0.001 (0.016)
ln(imports 99)	0.007 (0.030)	0.015 (0.024)
ln(Swe control)	-0.519 (0.619)	-0.244 (0.497)
No. of obs.	202	202
Adj. R^2	.02	.02

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 Labour 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.

Moving down to the firm level again, a different picture emerges. Controlling for size and skill intensity, Table 6 shows that exposed firms 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; Labour productivity, skill intensity, size and net exposure

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

The econometric analysis confirms these descriptives. Counter to what one possibly would expect, the real appreciation appears to have boosted productivity growth within firms, see Table 7. Our results suggest that the higher net exposure, the greater the increase in firm productivity growth.

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 most significant contribution to the increase in productivity growth came from the firms most exposed to the RER shock. As discussed above, these were also the firms having to take the largest cut in employment (in terms of man hours). Based on the estimated coefficients for the impact of net exposure on productivity, we infer that the RER shock was responsible for a 2.6 percent rise in the labor productivity and a 2.2 rise in TFP. Hence, 1/7 of the improvement aggregate labor productivity growth and 1/5 of the improvement in total factor productivity growth in manufacturing can be ascribed to the real appreciation shock.

Table 7: Firm level, 2LS (9900 vs. 0204)

	LP	TFP
Net exposure (Λ)	1.698** (0.843)	1.524* (0.805)
ln(firm size 99)	−0.018 (0.015)	−0.008 (0.014)
ln(earnings 99)	−0.199*** (0.041)	−0.159*** (0.040)
ln(labprod 99)	0.343*** (0.032)	0.288*** (0.031)
ln(skill intensity)	−0.028 (0.031)	−0.019 (0.030)
ln(exports 99)	−0.005 (0.006)	−0.003 (0.006)
ln(imports 99)	−0.003 (0.007)	−0.005 (0.007)
ln(Swe control)	−0.729* (0.423)	−0.741* (0.403)
No. of obs.	1710	1710
Adj. R^2	.1	.09

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 Labour 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.

4.4 Firm structure

Finally we address the question of whether the RER shock affected firms' structure. We look at three key variables: FDI (measured by foreign affiliates sales), outsourcing internationally (measured by share of imports in intermediates), and export share. The changes in firms' internationalization strategies are very much in line with what we would expect. The firms that suffered the most from the real appreciation decreased their exports activities, making them less vulnerable towards a future RER shock. The same firms also increased their natural hedge by outsourcing a greater share of their intermediates from abroad.

Table 8: Firm level, 2LS (9900 vs. 0204)

	FDI	*Impshare*	*Expshare*
Net exposure (Λ)	9.034 (5.449)	6.739*** (2.201)	−12.971*** (4.105)
ln(firm size 99)	0.028 (0.110)	−0.080** (0.036)	−0.007 (0.087)
ln(earnings 99)	0.231 (0.432)	−0.296*** (0.109)	0.533** (0.233)
ln(labprod 99)	−0.172 (0.323)	0.026 (0.083)	−0.362** (0.169)
ln(skill intensity)	0.044 (0.268)	0.040 (0.078)	0.115 (0.154)
ln(exports 99)	−0.061 (0.097)	−0.082*** (0.017)	0.237*** (0.036)
ln(imports 99)	0.060 (0.079)	0.165*** (0.021)	−0.135*** (0.039)
ln(Swe control)	1.251 (1.266)	−0.837 (1.018)	4.712* (2.631)
No. of obs.	41	1582	1317
Adj. R^2	0.28	0.05	.08

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), Share of imports in intermediates (*Impshare*), and Share of exports in sales (*Expshare*). *** significant at the .01 level, ** significant at the .05 level, * significant at the .1 level. Standard errors in parenthesis.

4.5 Econometric issues and robustness

4.5.1 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 quit. This may or may not be true, but in any case this factor will tend to bias our results in the direction of not finding any RER effects. One would think that if selection is an issue, the failing firms responded more strongly to the RER shock than continuing firms, not the other way around. Secondly, our simple logit estimation showed that there was no systematic correlation between firm exit and net exposure, controlling for other factors, suggesting that selection is not a big issue.

4.5.2 Terms of trade

One may argue that the effect on export and import volume is difficult to assess because the appreciation lowered export prices measured in Norwegian currency (assuming for example sticky nominal prices measured in foreign currency[12]). The estimates will thus only reflect the decline in the price of exports. In general, this is not a problem in our model because price movements affecting all sectors or firms simultaneously will be subsumed into the θ term. A more relevant issue, however, is whether relative price movements between sectors/firms will bias our results. To avoid this, we have deflated export values by 2 digit export price deflators (see appendix for further details).

4.5.3 IV results - Hausman test

Table A3 in the appendix reports p-values for Hausman tests for our firm-level specifications. Specifically, we are interested whether we can reject the null that the Swedish control is exogenous. The column shows that the p-values are high in all specifications, implying that we cannot reject the null of exogeneity.

Comparing the IV-results with regressions without the Swedish control (results available upon request) shows that the coefficient estimates of β are fairly similar across specifications. This suggests that our difference-in-difference approach is robust and that time varying industry characteristics are not systematically correlated with net exposure.

4.5.4 Import competition

Our identification strategy implies that RER effects which run through import competition - for example that the 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 net exposure and import competition. For example, if the negatively exposed firms ($\Lambda_{ij} < 0$) face a higher degree of foreign competition at home than the positively exposed firms, then our estimate of β will be biased downwards.

[12] If all prices are sticky, a nominal appreciation will decrease the terms of trade. For example, if the Krone appreciates against the Euro, the € price of Norwegian exports will remain fixed, but the NOK price will decline, whereas the price paid for imports in Norway will remain fixed.

We therefore consider a regression that includes a control for industry-level import competition as well. Import competition is here defined as total import value relative to total absorption in our base year. We report estimation results and details about the construction of the import competition variable in the appendix (table A4). The coefficient estimates are nearly unchanged, which indicates, as we suspected, that omitted variable bias is not an important issue here.

4.5.5 Net versus gross exposure

We have so far only considered the importance of net exposure relative to the RER shock. Here we ask whether export or import exposure has a symmetric effect, or in other words, whether net exposure is the most relevant variable to include in the analysis. A simple test is to estimate the following model

$$\Delta y_{ij1} - \Delta y_{ij0} = \theta + \beta_1 k \lambda_{ij} + \beta_2 k \widetilde{\lambda}_{ij} + \gamma(\Delta y_{1t}^{SE} - \Delta y_{0t}^{SE}) + \phi \mathbf{x}_{ij99} + v_{ij}$$

where $k = \Delta p_1 - \Delta p_0$. We then test whether $\widehat{\beta}_1 = -\widehat{\beta}_2$. The test statistic is distributed $F(h, N-K)$ under H_0. We obtained relatively large p-values, regardless of which variables were used as dependent variables. We conclude that we cannot reject the hypothesis that the response is symmetric, indicating that using net exposure is appropriate.

4.5.6 Exclusion of controls

We also evaluate the sensitivity of the results to the inclusion of controls. Column 3 in table A4 in the appendix reports a firm-level specification excluding all controls, estimated with OLS. In the models for employment and productivity, the parameter estimates are somewhat lower than previous specifications, but still significant. This indicates that net exposure is not highly correlated with other covariates as well as the error term. In the models for export and import share, however, the coefficient estimates change sign. One interpretation is that highly exposed firms were generally experiencing high export growth rates, possibly because exposure is correlated with various favorable firm characteristics. Holding the level of exports constant, however, reveals that net exposure had a negative effect on the export share.

5 Conclusions

To be written.

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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[13].

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[14].

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[15].

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). ω_{it} is unobserved productivity and η_{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 $R^k_{it} = (r + \delta_k)K^k_{it}$, where K^k_{it} is the real net capital stock of type k, for firm i

[13] http://www.ssb.no/english/subjects/08/03/40/uhvp_en

[14] http://ssb.no/nr_en/input-output.html

[15] 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[16] (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) [17]. 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 β.

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[18] and then manually linked to the Norwegian dataset.

Further details on the variables in the database are provided by Raknerud, Rønningen and Skjerpen (2005)[19].

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[16] The latter group consists of machinery, equipment, vehicles, movables, furniture, tools, etc.

[17] http://www.regjeringen.no/nb/dep/aid/tema/Inntektspolitikk/rapporter-fra-tbu.html

[18] http://www.ssd.scb.se/databaser/makro/Produkt.asp?produktid=NV0109

[19] http://www.ssb.no/english/subjects/10/90/doc_200416_en/doc_200416_en.pdf

A.2 Tables

Table A1: Net currency exposure and growth, industry level

		Employment			*Hours*		
nace	Λ	Δ_0	Δ_1	$\Delta_1 - \Delta_0$	Δ_0	Δ_1	$\Delta_1 - \Delta_0$
18	-0.18	-15.8	-4.8	11.0	-13.8	-11.3	2.6
30	-0.09	-67.7	-24.8	42.9	-69.3	-30.8	38.5
22	-0.04	-5.9	-5.0	0.9	-2.1	-4.4	-2.3
15	-0.03	3.5	-4.1	-7.7	2.8	-7.0	-9.9
26	-0.02	-2.2	-3.1	-1.0	-0.1	-7.0	-6.9
20	-0.01	2.6	-1.1	-3.7	4.0	-1.3	-5.4
17	-0.01	-3.9	-5.3	-1.4	-1.8	-9.3	-7.5
25	0.00	-6.3	-6.0	0.4	-9.1	-8.4	0.7
28	0.01	-9.6	-3.2	6.4	-10.8	-4.4	6.5
35	0.03	-10.3	-3.7	6.7	-10.2	-6.9	3.3
31	0.04	-17.1	6.4	23.5	-11.2	9.8	21.0
36	0.07	-2.2	-3.0	-0.8	-0.9	-3.0	-2.1
37	0.15	11.5	3.7	-7.8	7.0	-4.9	-11.9
19	0.15	-19.8	-3.1	16.7	-18.5	-3.2	15.3
29	0.22	2.4	-3.0	-5.4	2.5	-4.9	-7.3
33	0.24	0.9	-14.5	-15.4	-1.3	-15.2	-13.9
27	0.25	11.4	-1.6	-13.0	18.6	-6.1	-24.8
32	0.3	18.2	-13.6	-31.8	21.8	-14.8	-36.6
24	0.32	13.1	3.2	-9.9	15.1	0.2	-14.8
21	0.38	-7.0	-2.4	4.6	-3.5	-7.7	-4.2
34	0.43	-3.9	-4.7	-0.9	0.3	-7.1	-7.4

Table A2: Net currency exposure and growth, industry level

		Laborproductivity			*TFP*		
nace	Λ	Δ_0	Δ_1	$\Delta_1 - \Delta_0$	Δ_0	Δ_1	$\Delta_1 - \Delta_0$
18	-0.18	25.2	12.6	-12.5	20.0	17.1	-2.9
30	-0.09	-47.0	42.8	89.8	-57.4	30.9	88.3
22	-0.04	-2.3	7.2	9.5	-2.1	6.6	8.7
15	-0.03	7.4	2.7	-4.7	9.3	5.3	-4.0
26	-0.02	4.6	6.3	1.6	1.3	8.5	7.2
20	-0.01	11.0	7.8	-3.2	6.6	8.8	2.2
17	-0.01	4.9	3.6	-1.2	1.2	4.9	3.8
25	0.00	-8.5	3.3	11.8	-9.9	4.3	14.2
28	0.01	-12.1	3.2	15.3	-12.6	1.9	14.5
35	0.03	-5.6	7.3	12.9	-9.9	10.4	20.3
31	0.04	10.2	11.4	1.3	0.2	9.4	9.2
36	0.07	5.5	10.6	5.1	2.8	7.1	4.2
37	0.15	25.0	15.5	-9.5	25.4	25.4	0
19	0.15	10.5	12.7	2.2	10.5	1.8	-8.7
29	0.22	4.5	-0.9	-5.4	-0.7	-0.1	0.6
33	0.24	3.1	-0.5	-3.6	1.6	-11.2	-12.9
27	0.25	30.7	13.2	-17.5	29.4	18.3	-11.1
32	0.3	23.2	13.3	-9.9	20.5	12.5	-7.9
24	0.32	21.1	2.4	-18.6	30.5	4.6	-25.8
21	0.38	28.2	10.2	-18.0	14.7	14.9	0.3
34	0.43	-9.4	8.9	18.3	-11.4	9.8	21.2

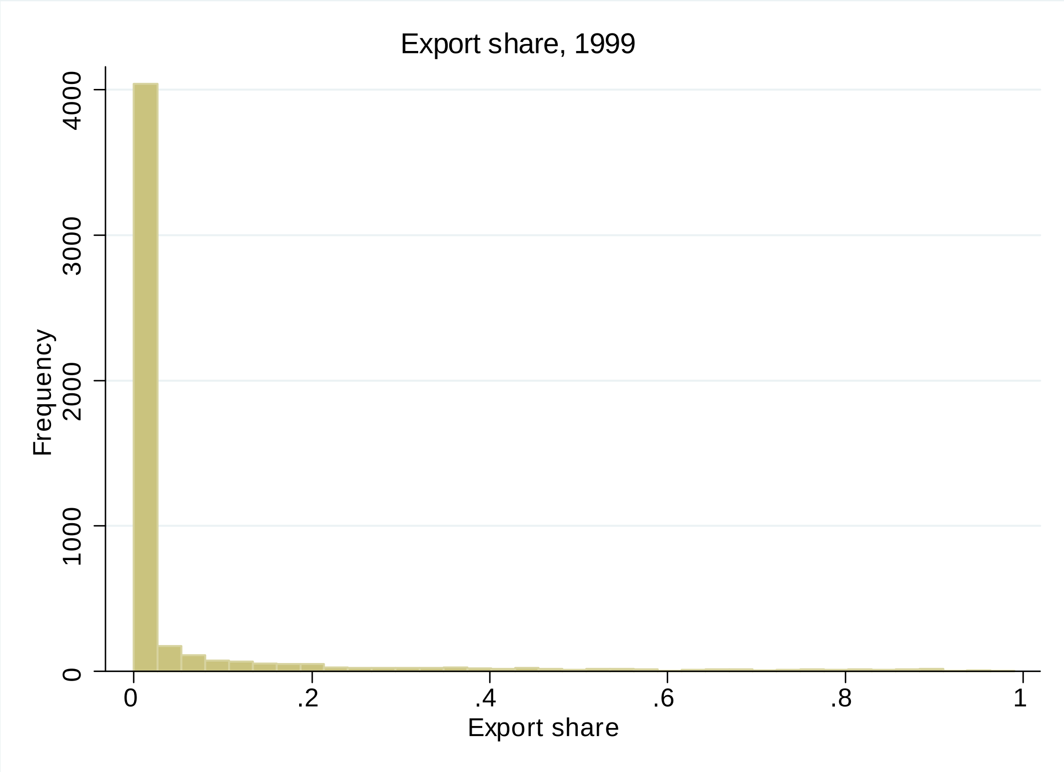
Table A3: Hausman tests - firm level regressions.

LHS variable	$\chi^2(8)$	p-value
Employment	.17	1.000
Hours worked	1.02	.998
Labor productivity	3.35	.911
TFP	3.87	.869
Export share	3.43	.904
Import share	.49	.999
FDI	1.09	.998

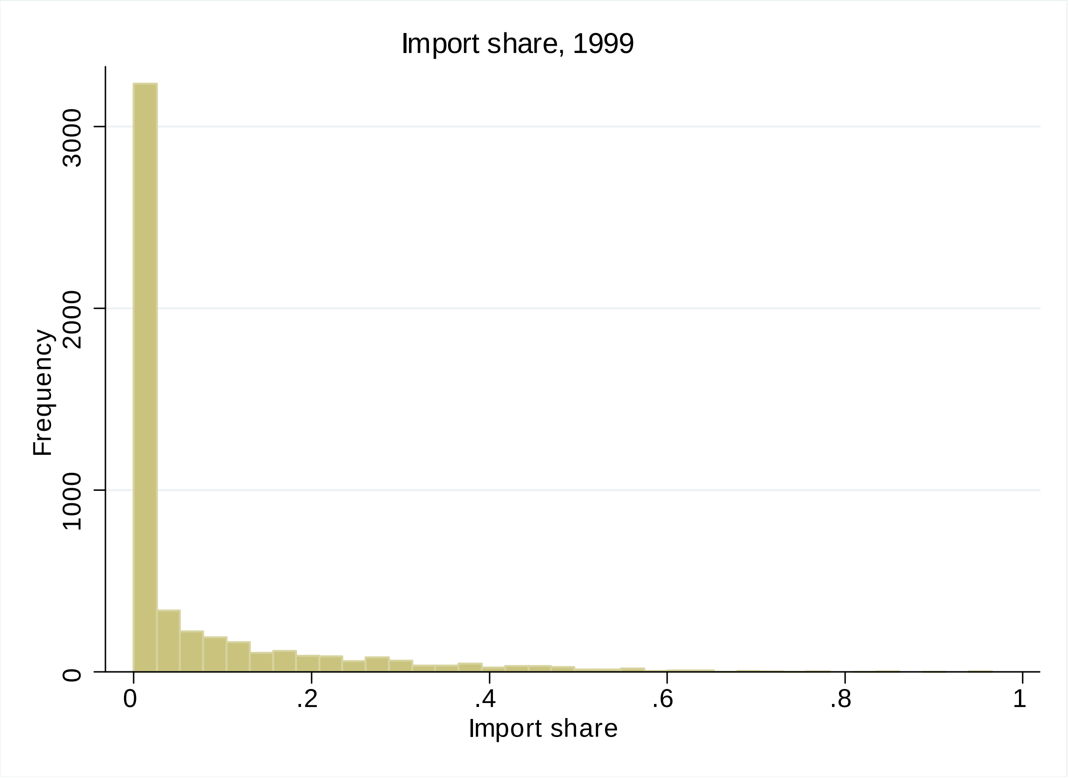
Table A4: Alternative control sets - firm level regressions.

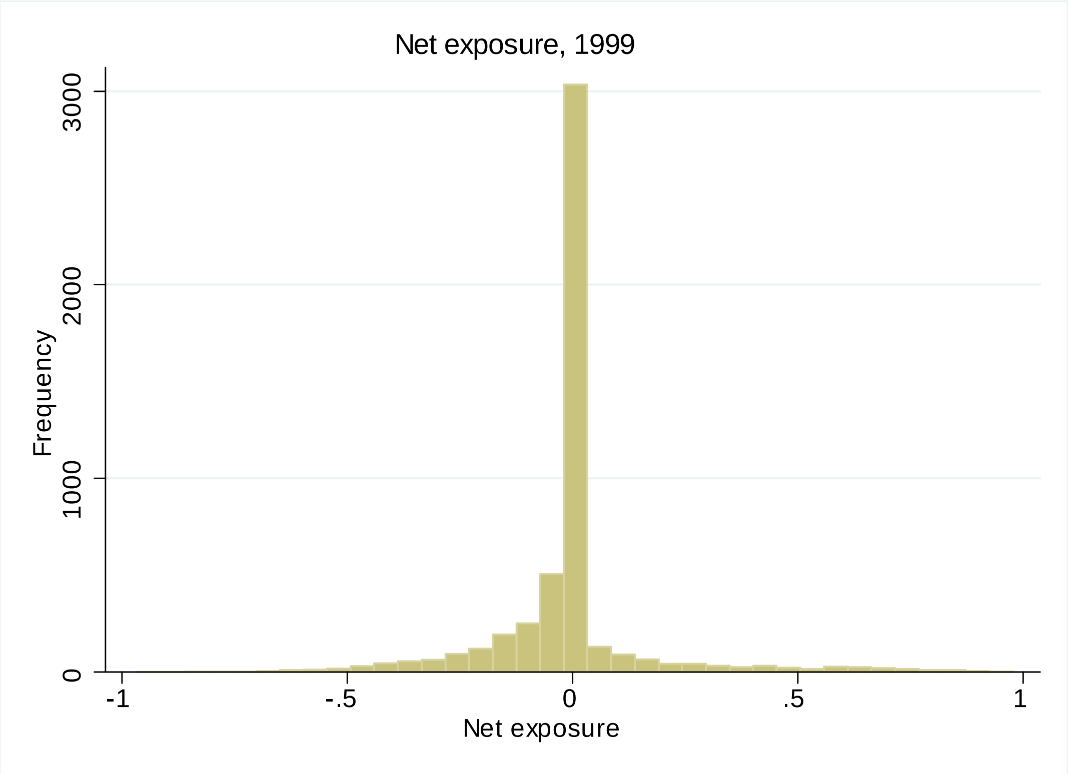
LHS variable	β IC	β NC
Employment	−0.749 (.567)	−0.719* (.369)
Hours worked	−1.602** (.649)	−0.834** (.416)
Labor prod	1.854** (.872)	0.929** (.455)
TFP	1.588** (.799)	1.278*** (.402)
Export share	−12.320*** (2.998)	6.418*** (1.877)
Import share	6.687*** (2.251)	−3.517** (1.484)
FDI	8.677 (5.662)	7.010*** (2.320)

Note: IC = Import competition control, NC = No controls. *** significant at the .01 level, ** significant at the .05 level, * significant at the .1 level. Standard errors in parenthesis.



Export share, 1999
Frequency
0
1000
2000
3000
4000
0
.2
.4
.6
.8
1
Export share


Import share, 1999
Frequency
0
1000
2000
3000
0
.2
.4
.6
.8
1
Import share



Net exposure, 1999
Frequency
0
1000
2000
3000
-1
-.5
0
.5
1
Net exposure