Exchange Rates and Producer Prices: Evidence From Micro-Data*

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December 2007

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Abstract

We make use of a unique data set that matches a monthly survey of output prices with annual plant census data to estimate the effect of demand and cost shocks driven by exchange rates on the extensive and intensive margin of pricing behavior. The crucial features of the data that allow us to identify responses to demand and cost shocks are, first, the fact that we observe prices for the same product being sold by the same plant in multiple markets that are segmented by variable exchange rates. Second, we observe prices for multiple plants, differentially exposed to exchange rates on the cost side, selling the same product in the home market. We find evidence of state-dependence of price setting in response to demand and cost shocks driven by exchange rate changes. Moreover, conditional on prices changing, we find that relative markups increase in response to increases in relative demand and fall in response to reductions in relative demand. Both of these observations are at odds with the standard assumptions of Calvo pricing and constant markups conventionally used to match the behavior of real exchange rates.

Keywords:

JEL Classification: F31, F41, L11, L16

1 Introduction

We know from a variety of different international macro models that the behavior of real exchange rates depends on firms' pricing behavior. It depends on whether prices are sticky,

*We thank the staff of the Central Statistics Office for making this project possible.

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the nature of price stickiness (state-dependent versus time-dependent pricing) and the currency in which export/ import prices are set. It also depends on the way in which prices and markups respond to demand and cost shocks driven by changes in nominal exchange rates. Some important examples of this literature include Obstfeld and Rogoff (1995), Betts and Devereux (2000), Bergin and Feenstra (2001), Chari, Kehoe and McGrattan (2002), Atkeson and Burstein (2007) and Kehoe and Midrigan (2007). In this paper, we exploit a unique dataset to document pricing behavior in domestic and export markets along two of these dimensions. We find strong evidence that the timing of price changes (the extensive margin) responds to shifts in relative demand and relative costs driven by exchange rate changes. We also find evidence that when prices are adjusted, markups change in response to shocks to relative demand (the intensive margin). In particular, we find that markups increase in response to increases in demand and decrease in response to reductions in demand.

The data that we exploit is based on merging the Irish Census of Industrial Production (CIP) with the micro data used to construct the Irish Producer Price Index (PPI). The producer price data is drawn from a sub-sample of the plants covered by the CIP. The two data sets can be linked through a unique plant identifier. The plant-level data is annual, while the price data is monthly. Our sample period covers 1995-2004. The openness of the Irish manufacturing sector, both on the output and the input side means that nominal exchange rate changes are an important source of both demand and cost shocks. Over half of plants are exporters, and between 60 and 80% of total sales are export sales. Over 70% of plants for which data is available report importing intermediates, and between 45 and 65% of total expenditure on intermediates is on imports. The largest single trading partner is the UK, with which Ireland has a floating exchange rate throughout the sample period.

The data set has two crucial features that allow us to identify responses to demand and cost shocks. First, we observe prices for the same product being sold by the same plant in both home and export markets. Movements in exchange rates between the home currency and the currency of the export market are perceived by the seller as relative demand shocks. Under the assumption that over a given horizon, changes in marginal costs are the same across different markets for a particular product produced by a particular plant, this allows us to identify the effect of demand shocks. Second, we observe prices for multiple plants selling the same product in the home market, while these plants are differentially exposed to exchange rate shocks on the cost side because of differences in their intensity of use of imported intermediates. Under the assumption that the shifts in demand faced by these plants over a given horizon are the same, we can identify the effect of cost shocks on pricing behavior. Since prices for most products are not continually adjusted, we consider separately the effect of demand and cost shocks on the extensive margin (whether prices are changed or not) and on the intensive margin (how prices respond conditional on adjustment).

This paper is closely related to the recent literature that uses micro data to explore price stickiness in consumer, producer and trade prices. In particular, it is related to Gopinath and Rigobon (2007) and Gopinath, Itskhoki and Rigobon (2007) who explore the responses of import and export prices to exchange rates using US data, and to Nakamura and Steinsson (2007) and the work of the European Inflation Persistence Network on producer prices in the US and Europe respectively [see Vermeulen et al. (2007) for a summary of the latter]. It is related more generally to the literature that aims to identify whether firms engage in state-dependent pricing, for example, Klenow and Kryvtsov (2007) and Midrigan (2007). Our approach to the identification of markup variation in response to shocks to relative demand driven by exchange rates closely follows Knetter (1989) and Knetter (1993) and differs from work such as Chevalier, Kashyap and Rossi (2003) and Eichenbaum, Jaimovich and Rebelo (2007) where markups are calculated directly from data on prices and costs.

The next section of the paper describes the data and provides some summary statistics. The third section outlines a partial equilibrium model of pricing behavior. The fourth section describes our empirical strategy. The fifth section presents results on the nature of price stickiness and the response of prices to demand and cost shocks. The final section concludes.

2 Data

Our data comes from two sources.[1] The first source is the Irish Census of Industrial Production (CIP). This census of manufacturing and mining sectors takes place annually, and is applied at both the firm and plant level (about 90% of plants are single-plant firms). All plants with 3 or more employees are required to fill in a return. The industries covered are

[1]The possibility for controlled access to the two confidential micro data sets on the premises of the CSO is provided for in the Statistics Act 1993. We are grateful to the Central Statistics Office for providing us with access to the two data sets, and assistance in merging them.

NACE Revision 1.1 (the harmonized European industrial classification system) classes 10 to 41. Our data covers the period 1991 to 2004. Of the variables collected, those relevant for our purposes are the industrial classification, country of ownership, value of sales, value of export sales (with some destination and currency invoicing information), employment, wage bill, materials costs (with share of materials imported, and some origin and invoicing information) and invoice currency. There is some information on investment, but we do not make use of it in this work. Further details on this data are provided in the Appendix.

The second source is the micro data collected for the purpose of constructing the Producer Price Index (PPI). The sampling frame for this data set is the population of plants in the CIP. Participation in the PPI is persistent, with periodic resampling from the CIP to maintain coverage. On average, 14% of CIP plants are included in the PPI sub-sample. Plants in this subsample are asked to provide transactions prices for a representative subset of their product range on a monthly basis. The explicit request is for a price drawn from an invoice dated on the 15th of the month in question. The definition of a product is usually very detailed, both in terms of the description of the item, and in terms of "price-determining variables" such as destination market, terms of sale and unit information. Participants are asked to discontinue a price series and replace it with another if there has been a change in any of these variables.

The price data is available for the period January 1995 to November 2006. The relevant variables for our purposes include prices, the currency in which the price is quoted, whether the good is sold domestically or exported, and for a limited subset of export observations, information about the destination market. Unfortunately, most of the "price-determining variables," including destination market, are available only for price quotes present in the last cross-section (November 2006), and as a result, we do not make extensive use of this information. Within plants, we frequently observe matched quotes for very disaggregated products sold in both home and export markets. Products are also matched across plants, usually at a sub-NACE 4-digit level of aggregation (but at a more highly aggregated level than 8-digit PRODCOM codes). The monthly price data is linked to the CIP plant data using a unique plant identifier. The empirical work in the remainder of the paper is based on this matched sample.

Summary statistics

On average, over 1995-2004, 14% of the universe of plants accounting for 32% of sales are included in the matched subsample. On the PPI side, 95% of price observations are matched to a plant in the CIP. We describe here summary statistics for the CIP as a whole, for the subsample of plants that are matched with the PPI data, and for the matched PPI data. Table 1 shows the year-by-year coverage in terms of number of plants, sales, export sales and employees. Clearly, plants in the matched sample are bigger and more export-intensive than average. This is confirmed by Tables 2 and 3, which report statistics on size, ownership, export status and import status for all plants and for plants in the matched sample in 1995 and 2004. In addition to being more export-intensive, plants in the matched sample are also more imported-intermediate intensive, and more likely to be foreign-owned. In an absolute sense, both matched and unmatched plants are very open on both the input and the output side. As such, they are probably not representative of firms in very closed economies, but they provide an ideal laboratory for examining the effects of exchange rate changes on pricing behavior. Table 4 reports the sectoral composition of the matched and unmatched samples. The matched sample is broadly representative of Irish industry.

Table 5 provides some summary statistics on the hierarchical structure of the price data. Between 550 and 900 plants are present in each annual cross-section. They provide between 4,200 and 5,900 price quotes per month, for between 900 and 1,400 products. The plants in our sample are multi-product producers, selling individual products in multiple different markets, both domestic and foreign. Most quotes are observed over prolonged periods of time. Figure 1 illustrates this by showing the evolution over the sample period of the 25th, 50th and 75th percentiles of the distribution of the length of time price quotes are in the sample. One notable feature of these spells is that for all spells a price is recorded for *every* month between the first time a particular quote is observed and the last month the quote is observed. Since it is implausible that all products in the sample are traded in every month, we are forced to conclude that at least some of the prices we observe are not transactions prices. Because of this, all statements that we make about the degree of price stickiness should be interpreted with caution. However we hope that where there are price changes, for those observations at least, we do observe something that relates to actual transactions.

3 Exchange rates and price-setting

To motivate our empirical work, we present a simple framework for analyzing price setting behavior. An important feature of the data that this framework must take into account is the fact that a very substantial fraction of price quotes do not change on a monthly basis, when measured in the currency in which they are set (we document this in section 5). This is typical of producer price data collected using surveys [see Vermeulen et al. (2007) and Nakamura and Steinsson (2007)]. Since we cannot be certain that we observe transactions prices (in fact, as noted above, we are fairly sure that we do *not* always observe transactions prices) we should be somewhat cautious about making statements about the degree of price stickiness. However we can be sure that prices are to some degree sticky. We consider the possibility of time-dependent and state-dependent pricing strategies, as well as some hybrid of the two. First, it is useful to consider the case of instantaneous adjustment.

3.1 No stickiness

We simplify along a number of dimensions. We do not address the possibility of an entry/exit margin.[2] We also assume that multi-product firms maximize profits separately for different products. The exposition here closely follows Knetter (1989). Consider a single-product firm i selling to K different destination markets, indexed by k. Demand in each market is assumed to take the form:

$$q^i_{kt} = f^i_k \left(p^i_{kt}/e_{kt}\right) y_{kt} \tag{1}$$

where q^i_{kt} is the quantity of i's good demanded by market k at time t, p is price in terms of the producer's currency, e is the exchange rate (producer's currency per unit of destination market currency) and y is a random variable that may shift demand. If the response of competitors is important, f^i_k should be thought of as a residual demand curve. We also assume that the price in market k does not depend on i's price in any other market (i.e. there is effective market segmentation).

Let firm i's costs be given by

$$c^i_t = c^i \left(\sum_k q^i_{kt}\right) z^i_t \tag{2}$$

[2] Although we observe extensive *product* entry and exit in our data, plant participation in the home and UK markets (the two we focus on most closely) is highly persistent.

where c_t^i measures costs in units of the producer's currency, and z is a random variable that may shift the cost function. Implicitly, this specification assumes that any trade costs are paid by the buyer, not the seller, and are not included in the price. As we will see later, we can relax this assumption to some degree. The firm's profit in period t is then:

$$\pi_t^i = \sum_k p_{kt}^i q_{kt}^i - c^i \left(\sum_k q_{kt}^i \right) z_t^i \tag{3}$$

Maximizing with respect to the home currency price charged in each market yields a set of first order conditions:

$$p_{kt}^i = mc_t^i \left[\frac{\eta_{kt}^i}{\eta_{kt}^i - 1} \right] = mc_t^i \mu_{kt}^i \tag{4}$$

where mc_t^i equals $\partial c^i / \partial q_{kt}^i \cdot z_t^i$, the marginal cost of production in period t (equal across markets) and η_{kt}^i is the elasticity of demand with respect to destination market currency price in destination market k:

$$\eta_{kt}^i = \frac{\partial q_{kt}^i}{\partial p_{kt}^{i*}} \frac{p_{kt}^{i*}}{q_{kt}^i}$$

This elasticity is conditional on the behavior of competitors. Given perfect price flexibility, if the firm were to set prices in the currency of the destination market rather than the home currency, the markup equation would be effectively unchanged:

$$p_{kt}^{i*} = mc_t^i \left[\frac{1}{e_{kt}} \frac{\eta_{kt}^i}{\eta_{kt}^i - 1} \right] = mc_t^i \frac{\mu_{kt}^i}{e_{kt}} \tag{5}$$

Exchange rates can affect the desired price through two channels, a demand channel and a cost channel. On the demand side, for a given producer currency price in market k, the destination currency price elasticity of demand varies with the exchange rate. Alternatively, for a given destination currency price, the normalized markup varies with the exchange rate. On the cost side, changes in exchange rates may affect the price of imported intermediate inputs. We are particularly interested in whether firms respond to either of these types of shock with some degree of markup adjustment. We will refer to this as the intensive margin of price adjustment. But before digging deeper, we must take account of the fact that prices may not be changed every period.

3.2 State-dependent pricing

We follow the literature in assuming that if there is state-dependence it takes the form of an (S,s) rule.[3] Firms re-optimize prices only if the absolute value of the percent deviation

[3]See Barro (1972), Caplin and Spulber (1987), Caballero and Engel (1993) among many others.

between desired prices and actual prices is sufficiently large. When they re-set prices, they set them to current desired prices. We assume that desired producer-currency prices are given by (4). This rule is optimal if desired prices are a random walk and there are fixed costs of changing prices. If the shocks that face firms are driven by floating exchange rates, the random walk assumption is reasonable, given that it is very difficult to reject the null of random walk behavior for exchange rates.

Suppose we are at date t. Let $s_k^i(t) < t$ be the last date on which firm i changed its price in market k. Then $\Delta_{t-s_k^i(t)} x_t$ is $x_t - x_{s_k^i(t)}$. Define:

$$g_{kt}^i = \Delta_{t-s_k^i(t)} \ln mc_t^i + \Delta_{t-s_k^i(t)} \ln \mu_{kt}^i \tag{6}$$

This is the percent deviation of the desired price from the actual price (i.e. the desired price the last time the price was reset). If firms follow an (S,s) rule, large positive and negative deviations will result in prices being reset. In between, there is a range of inaction. We allow for the possibility that the (S,s) band is not symmetric:

$$\begin{array}{lll} \Delta_{t-s_k^i(t)} \ln p_{kt}^i > 0 & \text{if} & g_{kt}^i > \bar{\rho} > 0 \\ \Delta_{t-s_k^i(t)} \ln p_{kt}^i = 0 & \text{if} & \underline{\rho} \leq g_{kt}^i \leq \bar{\rho} \\ \Delta_{t-s_k^i(t)} \ln p_{kt}^i < 0 & \text{if} & g_{kt}^i < \underline{\rho} < 0 \end{array} \tag{7}$$

Clearly, if desired prices depend on exchange rates, the likelihood of a price change under state-dependent pricing depends on exchange rates. We call this the *extensive margin* of price adjustment, in contrast to the *intensive margin* which captures how prices change conditional on adjustment.

3.3 Time-dependent pricing

There is a long tradition of assuming that firms price in a state-dependent fashion. While the classic Calvo sticky-price macro model represents this as prices changing with Poisson probability, this is not an assumption that we can take seriously at the micro level. However we observe seasonal patterns in the frequency of price adjustment that suggest that some firms may reassess prices in a time-dependent fashion. There is likely to be heterogeneity across firms and sectors in the frequency of time-dependent price adjustment. If firms strictly follow time-dependent rules, there is no extensive margin of price adjustment in response to exchange rate changes. If firms follow a mixture rule with both state and time-dependent components, there will be some extensive margin response to shocks, but a higher unconditional probability of price changes at some periods of the year than others.

4 Empirical strategy

In this section, we lay out a reduced-form strategy for identifying price responses to exchange rate shocks both on the extensive and the intensive margin. We start by considering demand shocks. Here, we build on Knetter (1989) and Knetter (1993). We then consider cost shocks driven by exchange rate changes. Finally, we describe our weighting procedure.

4.1 Demand shocks

In our data, we observe plants selling the same product in different markets. Consider the following specification for g^i_{kt}, the desired percent change in domestic currency price for product i in market k given the timing of the previous price change:

$$g^i_{kt} = \alpha + \theta^i_{t,s^i_k(t)} + \lambda_k + \beta_k \Delta_{t-s^i_k(t)} \ln e_{kt} + \varepsilon^i_{kt} \tag{8}$$

In this expression, $\theta^i_{t,s^i_k(t)}$ is a plant-month-age of price fixed effect, λ_k is a market fixed effect and ε^i_{kt} is an error term. Under the assumption that changes in marginal cost for a particular product are the same across markets over a given time interval, the plant-month-age of price fixed effect captures the percent change in marginal cost between t and the last time prices were changed. Note that as long as trade costs are fixed, it does not matter whether prices are measured inclusive or exclusive of trade costs. This fixed effect also captures any time-dependent elements in price-setting behavior. The market fixed effect captures any long-term trends in desired relative prices across markets.

$\Delta_{t-s^i_k(t)} \ln e_{kt}$ is the change in bilateral exchange rates since the last time the price of product i in market k was changed. As long as other potential shifters of relative demand across markets are orthogonal to this variable, β_k is the elasticity of the desired markup with respect to shifts in demand driven by exchange rates. More generally, β_k picks up the effect of shocks to relative demand that are correlated with exchange rate changes. This does not affect our conclusions about state-dependence of pricing behavior or relative markup variation in response to shocks. Specification (8) imposes that this elasticity is the same for all plants. We can relax this assumption by allowing it to vary by sector, plant size or other characteristics.

4.1.1 Extensive margin

As already noted, we do not observe g^i_{kt} every period, only when prices are changed in the currency in which they are set. Suppose we assume that ε^i_{kt} has a logistic distribution. Then

$$\Pr\left[\Delta_{t-s^i_k(t)} \ln p^i_{kt} > 0\right] = \Lambda\left(\alpha - \bar{\rho} + \theta^i_{t,s^i_k(t)} + \lambda_k + \beta_k \Delta_{t-s^i_k(t)} \ln e_{kt}\right) \tag{9}$$

$$\Pr\left[\Delta_{t-s^i_k(t)} \ln p^i_{kt} < 0\right] = \Lambda\left(-\alpha + \underline{\rho} - \theta^i_{t,s^i_k(t)} - \lambda_k - \beta_k \Delta_{t-s^i_k(t)} \ln e_{kt}\right) \tag{10}$$

where $\Lambda(z) = \exp(z)/1 + \exp(z)$. We can estimate these as conditional logit regressions. Identification of state-dependence is driven by cases where, given a previously synchronized price change, prices for a particular product are changed in one market, but not in another (we observe a degree of synchronization in price setting within plants, but it is not perfect). The thresholds for price adjustment are controlled for by the conditioning procedure that simultaneously eliminates the fixed effects $\theta^i_{t,s^i_k(t)}$, implicitly allowing for plant and time-interval specific thresholds. Note that the potential asymmetry across increases and decreases in (7) implies that (9) and (10) should be estimated separately.[4] Under the joint null of state-dependence in price setting and procyclical markups, we would expect to find $\beta_k > 0$ (remember e_{kt} is defined as the price of 1 unit of foreign currency in terms of home currency). Under the joint null of state-dependence and counter-cyclical markups, we would expect to find $\beta_k < 0$.

The identification strategy we describe depends on observing the same good sold by the same plant in at least two markets, where there is a variable exchange rate between those markets. In identifying markets other than the home market, we are constrained by the fact that our destination information for exports is poor. However for all export observations, we have information on the currency in which prices are set. When prices are set in currencies such as the dollar, this is not informative about the precise destination market. But for other currencies, we are fairly sure that we can identify a product with a particular market based on the invoice currency. In our baseline results, we restrict the sample to home market quotes invoiced in domestic currency and export quotes invoiced in Sterling, presuming that such exports are sold in the UK market. Since the UK is the largest single destination market

[4]Additionally, combining fixed-effects with ordered dependent variables is not straightforward.

for Irish exports, this yields a relatively large sample size. We recognize that this approach is not ideal. The choice of invoice currency is endogenous. There is evidence that pricing behavior differs systematically with the choice of invoice currency [Gopinath, Itskhoki and Rigobon (2007)], indicating selection. But given the constraints of the available data, this is the best we can do.

Given that we have multi-product producers, we use plant-product-month-age of price fixed effects to capture changes in product-specific marginal costs. In estimating (9), we code as zero observations where the price is not reset, and observations where the price is increased. Similarly, for (10), we code as zero observations where the price is not reset, and observations where the price is reduced. We weight observations by shares in in-sample yearly turnover as described below, and cluster standard errors at the firm level.

4.1.2 Intensive margin

Although we do not observe g^i_{kt} every period, we do observe it when prices are reset. If we condition on price changes taking place we can estimate:

$$\Delta_{t-s^i_k(t)} \ln p^i_{kt} = \alpha + \theta^i_{t,s^i_k(t)} + \lambda_k + \beta_k \Delta_{t-s^i_k(t)} \ln e_{kt} + \varepsilon^i_{kt} \tag{11}$$

It has been suggested by the survey literature on pricing behavior that firms tend to respond differently to positive and negative demand shocks [see Pelzman (2000) for the US and Fabiani et al. (2005) for the Euro zone]. We can allow for asymmetry by allowing the coefficient on appreciations and depreciations to differ:

$$\Delta_{t-s^i_k(t)} \ln p^i_{kt} = \alpha + \theta^i_{t,s^i_k(t)} + \lambda_k + \beta^+_k \Delta_{t-s^i_k(t)} \ln e^+_{kt} + \beta^-_k \Delta_{t-s^i_k(t)} \ln e^-_{kt} + \varepsilon^i_{kt} \tag{12}$$

Here $\Delta_{t-s^i_k(t)} \ln e^+_{kt}$ is positive when the exchange rate change is positive, and zero otherwise, and conversely for $\Delta_{t-s^i_k(t)} \ln e^-_{kt}$.

If relative markups are constant in the face of relative demand shocks, we expect to find β_k, β^+_k and β^-_k not significantly different from zero. On the other hand, if markups increase in response to positive demand shocks and decrease in response to negative demand shocks (procyclical markups) we would find β_k, β^+_k and $\beta^-_k > 0$. Conversely, if markups are countercyclical in response to demand shocks, we would have β_k, β^+_k and $\beta^-_k < 0$.

We are able to identify the change in marginal cost between t and $s^i_k(t)$ using $\theta^i_{t,s^i_k(t)}$ if price changes are synchronized in at least two markets in which the plant sells a given product, conditional on previous price changes in those markets also being synchronized. This implies that our identification of the intensive and extensive margins of price adjustment comes from disjoint sets of observations (remember that the extensive margin can only be identified in cases where prices change in one market but not the other, conditional on a previously synchronized price change).

As in the case of the extensive margin, we restrict our sample to home sales invoiced in domestic currency and export sales invoiced in Sterling, identifying the export quotes with the UK market. In estimating (11) and (12) we weight by turnover shares and cluster standard errors at the plant level.

4.2 Cost shocks

Suppose we observe multiple plants selling the same product in the same market. Let j denote a particular product. Suppose further that we observe cost shocks z_t^i that are heterogeneous across plants indexed by i that sell good j. Consider the following specification for the desired change in prices denominated in domestic currency:

$$g_{kt}^i = \gamma + \phi_{k,t,s_k^i(t)}^j + \delta_k \Delta_{t-s_k^i(t)} \ln z_t^i + \varepsilon_{kt}^i \tag{13}$$

In this expression, $\phi_{k,t,s_k^i(t)}^j$ is a product-market-month-age of price fixed effect, and ε_{kt}^i is the error term. If all plants selling good j in market k face the same shifts in residual demand over a given period of time, these shifts can be controlled for using this fixed effect, which also picks up any time-dependent pattern of price-setting. Clearly, the assumption that all plants face the same residual demand shifts is less defensible than the assumption that changes in marginal costs are the same for all markets in which a particular plant sells a particular good. In particular, it is unlikely to be valid when producers are large relative to the size of the market. Given this caveat, as long as other potential shifters of marginal cost are orthogonal to z_t^i, δ_k is the elasticity of the desired price change with respect to shifts in marginal cost driven by z_t^i. As in the demand case, this specification imposes that this elasticity is the same for all products and plants. We may relax this assumption by allowing the parameter to vary by sector, plant size or other characteristics.

The cost shock variable that we use is based on the observation that there is persistent heterogeneity across plants in their intensity of use of imported intermediates. We have information on the share of intermediates imported from the UK and the share imported from the US. We interact the initial share of intermediates imported from each of these two countries in marginal cost (wage bill plus expenditure on intermediates) with the accumulated log change in the relevant exchange rate to obtain:[5]

$$\Delta_{t-s_k^i(t)} \ln z_t^i = \sum_{k=UK,US} sh^i_{k,s_k^i(t)}(k)\, \Delta_{t-s_k^i(t)} \ln e_{kt} \tag{14}$$

where

$$sh^i_{k,s_k^i(t)}(k) = \frac{Materials^i_{k,s_k^i(t)}(k)}{\sum_{k=1}^{K} Materials^i_{k,s_k^i(t)}(k) + Wages^i_{s_k^i(t)}} \tag{15}$$

For the case of the UK share, 78% of the variation in our panel of plants is explained by plant fixed effects. For the US case, 83% of the variation is explained by plant fixed effects. Note that the share variable is observed only at an annual frequency, while exchange rate changes are calculated on a month-to-month basis.

4.2.1 Extensive margin

We do not observe g^i_{kt} every period, only when prices are changed in the currency of denomination. If we assume that ε^i_{kt} has a logistic distribution, then:

$$\Pr\left[\Delta_{t-s_k^i(t)} \ln p^i_{kt} > 0\right] = \Lambda\left(\gamma - \bar{\rho} + \phi^j_{k,t,s_k^i(t)} + \delta_k \Delta_{t-s_k^i(t)} \ln z_t^i\right) \tag{16}$$

$$\Pr\left[\Delta_{t-s_k^i(t)} \ln p^i_{kt} < 0\right] = \Lambda\left(-\gamma + \underline{\rho} - \phi^j_{k,t,s_k^i(t)} - \delta_k \Delta_{t-s_k^i(t)} \ln z_t^i\right) \tag{17}$$

We can estimate these as conditional logit regressions, using the cases where some but not all prices change in the relevant direction (given previously synchronized price changes) to identify the coefficient δ_k. The conditioning procedure to remove the fixed effects $\phi^j_{k,t,s_k^i(t)}$ implicitly controls for variation across time and across products, but not across plants, in the adjustment thresholds. As in the demand case, the asymmetry in (7) suggests estimating separate equations for increases and decreases. Under the joint null hypothesis that there is positive pass-through of cost shocks into prices and state-dependence in price setting in response to cost shocks, $\delta_k > 0$.

The identification strategy relies on observing at least two plants selling the same product in the same market. In our data, the largest single market is the home market. For other

[5] The remaining share of imported intermediates is broken down between the share imported from the EU, and the share imported from the rest of the world. This information is not sufficiently precise to tell us the appropriate bilateral exchange rate.

identifiable markets (e.g. the UK market as identified in the demand shock case) there are very few observations of two or more plants selling the same product, so we restrict attention to home sales (invoiced in home currency). Products are defined at the most disaggregated level possible in the data. This level is generally more disaggregated than NACE 4-digit sectors, but more aggregated than 8-digit PRODCOM codes. Price increases and decreases are coded exactly as in the demand shock case. We weight observations by turnover shares and cluster standard errors at the plant level.

4.2.2 Intensive margin

Analogous to the demand case, if we condition on prices being reset, we can estimate:

$$\Delta_{t-s_k^i(t)} \ln p_{kt}^i = \gamma + \phi_{k,t,s_k^i(t)}^j + \delta_k \Delta_{t-s_k^i(t)} \ln z_t^i + \varepsilon_{kt}^i \tag{18}$$

or if we allow for asymmetry:

$$\Delta_{t-s_k^i(t)} \ln p_{kt}^i = \gamma + \phi_{k,t,s_k^i(t)}^j + \delta_k^+ \Delta_{t-s_k^i(t)} \ln z_t^{i+} + \delta_k^- \Delta_{t-s_k^i(t)} \ln z_t^{i-} + \varepsilon_{kt}^i \tag{19}$$

In order for $\phi_{k,t,s_k^i(t)}^j$ to pick up demand shocks, we must condition on at least two plants selling product j in market k changing prices, given that their last price changes were also synchronized. Because price changes are not very synchronized across plants (much less synchronized than within plants) this reduces drastically the sample size for estimation.

With that caveat, if prices do not respond to cost shocks, we would expect to find δ_k, δ_k^+ and δ_k^- not significantly different from zero. On the other hand, if there is some pass-through of cost shocks to customers, we expect δ_k, δ_k^+ and $\delta_k^- > 0$. A value of $\delta_k = 1$ indicates one-for-one pass-through of cost shocks, i.e. zero markup adjustment. We condition on sales in the home market invoiced in domestic currency. We weight observations by turnover shares and cluster standard errors at the plant level.

4.3 Weighting procedure

We can weight observations at a much greater level of disaggregation than is usual in studies that use micro price data. For a given year, within a plant and destination market category (home price quote or export price quote) all quotes have equal weight. Across destination market categories and plants, weights are given by plant-level turnover broken down by domestic and export sales as a share of total within-sample turnover for the relevant year. For example, suppose plant i reports J_{ht}^{i} price quotes in the home market at time t and total home sales of $SALES_{ht}^{i}$ in that year. Then the weight for a price quote for a given product j sold by this plant in the home market at time t is given by:

$$w_{ht}^{ij} = \frac{\frac{1}{J_{ht}^{i}} SALES_{ht}^{i}}{\sum_{i=1}^{N_t} \sum_{k=h,e} SALES_{kt}^{i}}$$

If this plant reports J_{et}^{i} price quotes in the export market, the analogous weight for an export price quote is:

$$w_{et}^{ij} = \frac{\frac{1}{J_{et}^{i}} SALES_{et}^{i}}{\sum_{i=1}^{N_t} \sum_{k=h,e} SALES_{kt}^{i}}$$

One problem with this weighting scheme is that because of the possibility of transfer pricing, turnover weights for some foreign multinationals may misrepresent true sales.

5 Results

Before moving to our results on the extensive and intensive margins of price adjustment to demand and cost shocks, we briefly lay out some summary statistics on the frequency and size of price changes. Our sample period, 1995-2004, is one of somewhat variable PPI inflation, as illustrated in Figure 3 (CPI inflation is reported for comparison). Since our goal is to argue that price adjustment is infrequent to a degree that is similar to other countries for which data is available, we do not focus on time series variation, but report summary statistics for the period as a whole.

5.1 Frequency and size of price adjustment

Table 6 reports the mean frequency of price adjustment overall, for home sales and exports, by currency of denomination, by two classifications of type of good and by plant size. The first column reports the relevant number of observations. The next three columns report frequencies of adjustment in denomination currency, unweighted, weighted by turnover shares, and weighted with an adjustment to treat product exit as a price change. The fifth and sixth columns report weighted frequencies of price increases and price decreases in denomination currency. The last two columns report the frequency of price changes in domestic currency, unweighted and weighted.

From the perspective of pricing behavior, the columns in Table 6 showing frequency of adjustment measured in denomination currency are of greatest interest. Clearly, prices are sticky in the currency in which they are set. The overall weighted mean frequency of price adjustment of 0.14 implies a weighted mean duration of prices of 6.6 months, calculated as $d = -1/\ln(1-f)$. The overall frequency of price changes is somewhat lower than that reported by Vermeulen et al. (2007) for six Euro zone countries, and by Nakamura and Steinsson (2007) for the US. This may be partly due to the fact that we are measuring stickiness in denomination currency rather than home currency, or to the difference between our weighting scheme and theirs.

The price changes actually used to construct producer price inflation are those measured in domestic currency (Irish pounds or Euros), i.e. the final two columns. The currency breakdown illustrates that these much higher frequencies are due to stickiness in denomination currency combined with floating exchange rates.

Since we cut the data in similar ways in presenting the results on the extensive and intensive margin, it is worth saying something about the breakdown of different goods that we use. The first breakdown of goods into different types is a classification of NACE 4-digit sectors used by Vermeulen et al. (2007). NACE sectors 10-41 are divided into consumer food products, consumer non-food non-durables, consumer durables, intermediates, energy or capital goods. Consumer food products, intermediates and capital goods are the most important sectors in our data. The other breakdown we use is based on the Rauch (1999) classification of 4-digit SITC sectors as traded on an organized exchange, reference-priced or differentiated. The match between our 4-digit NACE (production) sectors and 4-digit SITC (trade) sectors is far from perfect, and many NACE sectors in our data do not have a Rauch classification. More details of these classifications are provided in the Appendix. We also report frequencies by plant size. Because of the transfer pricing issue, we use an employee-based measure of size. Plants are allocated to size classes on the basis of their median size over the sample period.

There is considerable heterogeneity across type of good in the degree of price stickiness [Table 7]. In terms of the Vermeulen classification, the ordering of relative frequency of adjustment for goods of different types is roughly similar to that found by Vermeulen et al. (2007) for 6 Euro zone countries. The ranking of frequency of adjustment by Rauch classification is a little different to that found by Gopinath and Rigobon (2007) for US import and export prices. They find that reference-priced goods are considerably more flexible than differentiated goods, though they find that both import and export prices are adjusted much less frequently than prices in our sample.

As others have found [Vermeulen et al. (2007), Nakamura and Steinsson (2007)] it is normal to observe simultaneous price increases and decreases, not only across, but within sectors. Like Vermeulen et al. (2007), we find that the frequency of price increases is marginally higher than the frequency of price decreases. Nakamura and Steinsson (2007) find a much bigger gap in the frequency of price increases and decreases in US data. This may be due to differences in inflation rates. Alternatively, the contrast between the large gap we find for home sales and the almost equal frequency of increases and decreases for export sales implies that a bigger role for exports in Europe may explain the US-Europe differences.

Table 8 reports some summary statistics on the size distribution of price changes. These statistics are also based on the weighting scheme described above. Weighted mean price increases and decreases are somewhat bigger than those reported by Vermeulen et al. (2007) though the weighted medians are not too dissimilar. We find weighted median changes that are considerably smaller than those reported by Nakamura and Steinsson (2007) for the US.

In terms of timing, there appears to be some degree of time-dependence in price setting, with spikes in the frequency of price changes in January in many years. Figure 4 plots the (weighted) frequency of price changes in invoice currency month-by-month throughout the sample period.

To summarize, we find that producer prices in Ireland behave in a roughly similar way to those in six Euro zone countries and the US along the dimensions of frequency and size of price adjustment: We find that prices are sticky, and that there is likely to be some time-dependent dimension to price-setting behavior. This gives us some confidence moving forward that our results on the extensive and intensive margins of price adjustment will have general applicability.

5.2 Extensive margin: demand shocks

We first report the results in the demand shock case. The first lines of Tables 9 and 10 report our baseline estimation of (9) and (10). The estimation constrains parameters to be equal across sectors and plants of different sizes. We find evidence of state-dependent pricing in response to demand shocks in the sense that, for matched observations where we are able to use fixed effects to clean out changes in marginal cost, there is a statistically significant response of the probability of a price change to relative demand shocks driven by exchange rate changes. The estimated coefficients on the exchange rate change since the last price change are consistent with procyclical markup responses to demand shocks, and are significantly different from zero at the 5% level in the case of both price increases and price decreases.

This result is illustrated in Figure 5, which plots the probability of price increases and decreases in the UK market against exchange rate changes for an assumed value of the fixed effect of zero. The x-axis spans the range of exchange rate changes based on which the coefficients are identified. Probabilities are on the y-axis. One way to interpret the figure is as follows. If there is no change in the exchange rate, other things (i.e. costs) equal, the probability that a plant will increase its price is approximately the same as the probability that it will not increase its price, and similarly for decreases. But if there is a 5% month-on-month appreciation of the domestic currency against Sterling (the largest month-on-month change observed in the data), other things equal, the plant is 4 times more likely to decrease prices in the UK market than it is in the case of a 5% depreciation. Conversely, if there is a 5% depreciation of the domestic currency against Sterling, other things equal, the plant is 3.5 times more likely to increase prices in the UK market than if there is a 5% appreciation. It should be emphasized that these magnitudes are holding costs constant. In addition, our estimation procedure allows us to identify responses to demand shocks conditional on (S,s) bands. We have nothing to say about the size of these bands.

This result on state-dependence and procyclical markups in response to demand shocks is robust to cutting the data in various different ways, as the subsequent lines in Tables 9 and 10 illustrate. The estimated coefficients on the exchange rate change are always positive for price increases and negative for price decreases. The coefficient on exchange rate changes is almost always significantly different from zero for price decreases. In the case of price increases, there are some cases where the coefficient is not significantly different from zero.

This is very weakly supportive of the survey evidence described by Fabiani et al. (2005) where firms report being more likely to reduce prices in response to reductions in demand than they are to increase prices in response to increases in demand. Unfortunately, given the size of our baseline sample, it is not possible to estimate the relevant equations if we look at more disaggregated sectors, or cut by size and sector simultaneously, though the elasticity of demand is more likely to be similar across plants within size classes and finely disaggregated sectors.

5.3 Extensive margin: cost shocks

In the cost shock case, the first lines of Tables 11 and 12 report our baseline estimation of (16) and (17). The evidence in favor of state-dependent pricing in response to cost shocks is slightly more nuanced than in the demand shock case. The sign of the estimated coefficients on the cost shock are consistent with positive pass-through of costs into prices (higher costs imply higher prices, other things equal). However there is an asymmetry across price increases and price decreases. In the case of price increases, the coefficient on the cost shock is not significantly different from zero, while it is significantly different from zero at the 5% level in the case of price decreases. This is in contrast to the qualitative evidence presented in Fabiani et al. (2005) which suggests that price increases in response to increases in costs are more likely than price decreases in response to cost reductions. It should be noted yet again that our identifying assumptions are less likely to be satisfied, and the sample size somewhat smaller than in the demand shock case.

Figure 6 illustrates the cost results in the same way that Figure 5 illustrates the demand results. Other things equal (i.e. demand) a plant where half of variable cost consists of intermediates imported from the UK is 1.8 times more likely to respond to a 5% month-on-month appreciation of the domestic currency against Sterling with a price decrease compared with the case of a 5% depreciation against Sterling.

As noted in section 3, our identifying assumptions are more likely to be valid for plants which take competitors' prices as given than for plants that engage in strategic interactions. They are also more likely to be valid within sectors than across sectors. Subsequent lines of Tables 11 and 12 report estimates of (16) and (17) cutting the data in various different ways. The results are not nearly as robust as in the demand case. For price increases, in several cases, the coefficient on the cost shock is significantly negative, indicating that reductions in cost increase the probability of price increases. The pattern of results is somewhat more consistent for price decreases. In no case do we find that increases in cost significantly increase the probability of a reduction in price. For plants in the 20-49 and 50-249 size categories, for which our identification assumptions are most likely to be satisfied, lower costs significantly increase the probability of a reduction in price.

We conclude that there is strong evidence of state-dependent pricing in response to demand shocks, and somewhat weaker evidence of state-dependent pricing in response to cost shocks. Evidence on asymmetry of responses to positive and negative demand and cost shocks is mixed.

5.4 Intensive margin: demand shocks

The first lines of Table 13 and Table 15 report our baseline estimation of (11) and (12). As in the case of the extensive margin, the estimation constrains parameters to be the same across sectors and plants of different sizes. The estimation is conditional on observing price changes in invoice currency. The coefficient on exchange rate changes is identified if the price changes in both domestic and UK markets for a particular product-plant pair in a particular month, given that the previous price change in both markets for this plant-product pair was synchronized. When the responses to positive and negative demand shocks are constrained to be the same, the coefficient on the exchange rate change is significantly different from zero, indicating relative markup variation across markets in response to exchange rate movements. The sign of the coefficient on the exchange rate change indicates that relative markups increase in response to increases in relative demand and decrease in response to decreases in relative demand. This is consistent with the results on the extensive margin.

It is of note that the coefficient on negative shocks is not significantly different from one. Given that we identify the foreign market by choice of Sterling as invoice currency, the case where an exporter does not change prices in response to exchange rate movements implies an elasticity of exactly one. Unfortunately, we do not have enough data points where the foreign market is precisely identified and the invoice currency is domestic currency to allow us to test whether the behavior of exporters who invoice in home currency is different.

When responses are allowed to differ according to whether the shock to relative demand is positive or negative (Table 15), again, the coefficients are significantly different from zero, and indicate that markups increase in response to positive demand shocks and decrease in response to negative demand shocks. There is weak evidence of asymmetry in the size of the coefficients. The point estimate of the markup response to positive demand shocks (depreciation of the domestic currency against Sterling) is larger than the point estimate of the markup response to negative demand shocks. However the coefficients are not significantly different from each other, and neither is significantly different from one.

Subsequent lines of Tables 13 and 15 as well as Tables 14 and 16 report results for different subsets of the data. When symmetry is imposed, the coefficient on the exchange rate change is significantly different from zero and not significantly different from one for all cases except the largest plants. When allowing for asymmetry, the coefficient on exchange rate depreciations (positive demand shocks) is significantly different from zero in all cases, and not significantly different from one in all but the case of consumer non-food non-durables (where the coefficient is greater than one). The coefficient on exchange rate appreciations (negative demand shocks) is on average less precisely estimated, but still significantly positive in the majority of cases. Our estimates of the size of these responses are not sufficiently precise to allow us to relate differences across sectors and plants of different sizes to hypothesized differences in the elasticity of demand.

5.5 Intensive margin: cost shocks

Table 17 reports our baseline estimation of (18) and (19). The estimation is conditional on observing price changes in invoice currency. The coefficient on the cost shock is identified if there is a price change by at least two producers of a particular product sold in the Irish market in a particular month, given that the previous price change of those producers was synchronized. In neither the case of symmetry nor asymmetry across increases and decreases in costs are the coefficients on the cost shock variables significantly different from zero. The requirement for two consecutive synchronized price changes for at least two plants implies that the coefficients of interest are identified by a very small subset of the sample, which may account for the inability to estimate precise markup effects. Given the small baseline sample size in the case of cost shocks, we do not report results from cutting the sample further. We conclude that there is little evidence either in favor of or against markup adjustment in response to cost shocks.

5.6 Discussion

Our results provide direct evidence of state-dependent pricing behavior in response to shocks to demand and costs driven by exchange rates. We also demonstrate that plants vary markups across markets in response to movements in exchange rates, increasing relative markups in response to increases in relative demand and reducing markups in response to reductions in relative demand. This evidence clearly contradicts the standard assumptions of time-dependent pricing (usually Calvo pricing) and constant markups made in many models designed to match real exchange rate behavior. This begs two questions. First, how widely applicable are our results? Second, are these deviations economically significant: i.e. are they crucial to understanding the behavior of real exchange rates, and the failure of standard models to explain this behavior?

In answer to the first question, the structure of our data allows us to identify state dependence of prices and markup variation relatively cleanly. The exchange rate is a plausibly exogenous (and large) source of variation in demand and costs. But one disadvantage of the identification strategy is that it is quite demanding of the data. State dependence and markup variation are identified using distinct and small subsets of the full data set. Cutting the data by sector and plant size results in even smaller samples, and imprecise estimates. As a result, we cannot make strong statements about whether plants in some sectors engage more in state-dependent rather than time-dependent pricing compared to others, or about differences across plants of different sizes in their propensity to vary markups in response to shocks.

To undersand more precisely the economic significance of our results, it would be necessary to calibrate a model incorporating state-dependence and variable markups. While our estimation results do provide some guidance for such a calibration, they do not directly get at many of the parameters of interest. For example, while we can say that plants do engage in state-dependent pricing, we cannot say anything about the size of the (S,s) bands, since our fixed effect strategy for controlling for cost shocks also controls implicitly for the inaction bands. In addition, given the structure of our data, we cannot identify differences in pricing behavior across plants that invoice their exports in home currency and plants that invoice their exports in foreign currency. The results presented by Gopinath, Itskhoki and Rigobon (2007) suggest that selection in currency choice and differential behavior across firms invoicing in different currencies may be important, and a serious calibration exercise should take account of this. We leave such a calibration exercise for future research.

6 Conclusion

In this paper, we make use of a unique data set that matches a monthly survey of output prices with annual plant census data to estimate the effect of demand and cost shocks driven by nominal exchange rate movements on the extensive and intensive margins of pricing behavior. The crucial features of the data that allow us to identify responses to demand and cost shocks are, first, the fact that we observe price quotes for the same plant selling the same product in multiple markets which are segmented by variable exchange rates. Second, we observe prices for multiple plants which are differentially exposed to exchange rates on the cost side selling the same product in the home market. These features of the data allow us to control for relative cost shocks and relative demand shocks in turn using fixed effects. This allows a relatively clean identification of the dependence of the probability of a price change, and conditional on prices changing, the magnitude of that change, on exchange rate-driven demand and cost shocks.

We find evidence that the probability that prices are changed depends on shocks to demand and costs driven by exchange rate changes. An increase in relative demand due to a depreciation of the exchange rate increases the probability of a price increase. A reduction in relative demand due to an appreciation of the exchange rate increases the probability of a price reduction. This is consistent with our second result, that conditional on prices changing, relative markups increase in response to increases in relative demand and fall in response to reductions in relative demand (procyclicality of markups in response to demand shocks). We also find that a reduction in costs driven by exchange rates increases the probability of a price reduction.

The results we present are at odds with the standard assumptions of Calvo pricing and constant markups used to try to match real exchange rate behavior in calibrated models. Recent work has started to incorporate more realistic features of price-setting behavior into models of real exchange rates. We hope that the results presented in this paper will contribute to this literature by confirming the empirical relevance of state-dependence and markup adjustment, and encouraging future research to test the importance of these mechanisms in explaining real exchange rate volatility and persistence.

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Table 1: Coverage of matched sample (%)

Year	Plants	Employees	Turnover	Exports
1995	15	36	34	24
1996	14	34	33	24
1997	13	32	30	22
1998	13	30	29	22
1999	11	27	23	20
2000	11	29	24	22
2001	13	32	24	24
2002	15	40	36	30
2003	17	43	38	32
2004	18	46	38	35
Avg	14	35	31	26

Table 2: Summary statistics on CIP and merged sample: size, ownership

	1995		2004	
	PPI sample	CIP	PPI sample	CIP
Turnover in current 1,000 EUR				
p25	1,950	343	2,329	491
p50	5,417	1,009	7,648	1,250
p75	20,763	3,796	24,889	4,477
Number of employees				
p25	25	7	23	6
p50	58	15	49	13
p75	129	41	117	34
% of plants foreign-owned				
	34	16	30	13

Table 3: Summary statistics on CIP and merged sample: exports and imports

	1995		2004	
	PPI sample	CIP	PPI sample	CIP
% of exporting plants				
	75	60	75	47
% of overall turnover exported				
	58	65	73	79
% of turnover exported in exporting plants				
p25	18	7	14	7
p50	62	30	53	30
p75	96	82	97	85
% of turnover exported to the UK in exporting plants				
p25	4	2	2	1
p50	13	8	10	7
p75	34	22	28	20
% of plants importing materials				
	84	72	94	75
% of overall materials imported				
	41	46	62	65
% of imported materials in materials + wage bill				
p25	20	12	15	10
p50	40	29	36	26
p75	57	49	57	48
% of materials imported from the UK in materials + wage bill				
p25	5	3	3	3
p50	15	11	9	8
p75	31	25	23	18

Note: Information for imports is based on the roughly 80% of the population for which comparable information is available over the entire time period.

Table 4: Sectoral shares (Share in # plants, share in turnover)

		1995				2004			
NACE	Description	plants		turnover		plants		turnover	
		PPI	CIP	PPI	CIP	PPI	CIP	PPI	CIP
10-14	Mining	2	2	2	1	2	3	1	1
15-16	Food, Bev., Tobacco	21	18	43	32	18	14	25	21
17-19	Textile, Apparel, Leath.	10	9	2	3	7	5	1	1
20	Wood Products	5	5	1	1	5	6	1	1
21-22	Paper, Printing	5	12	4	9	7	13	7	15
24	Chemicals	7	5	18	16	7	4	19	24
25	Rubber, Plastics	5	5	3	2	6	6	2	1
26	Non-metallic min.	7	6	3	2	7	7	2	2
27-28	Metal, Metal prod.	11	12	2	3	11	14	3	2
29	Machinery	6	7	5	3	8	6	3	2
30-33	Electr. machinery	12	9	13	25	12	8	31	27
34-35	Transport equip.	3	3	1	2	2	2	1	1
36	Other manuf.	6	8	1	2	7	10	1	1
# plants/sum to(Mio EUR)		670	4,617	15,064	43,969	854	4,877	37,377	97,979

Table 5: Hierarchical structure of matched data

	3-dig. NACE	Plants	Plant-prd. pairs	Quotes	Obs.
1995	85	670	1,100	4,883	53,961
1996	85	647	1,065	4,788	52,079
1997	84	627	1,037	4,651	50,938
1998	85	596	1,010	4,804	49,162
1999	83	556	947	4,174	46,294
2000	86	581	978	4,499	46,932
2001	87	653	1,071	4,925	49,969
2002	91	808	1,234	5,452	53,143
2003	90	878	1,327	5,820	59,752
2004	91	854	1,297	5,370	58,681
total	96	1,169	1,891	11,811	520,911

Table 6: Mean adjustment frequency by export status and currency (%)

	Obs	Denomin. Currency					Home Currency	
		unw	wgt	wgt, adj. for exit	wgt inc	wgt dec	unw	wgt
total	442,553	11	14	17	8	6	27	40
Destination market								
home	289,197	11	16	17	11	5	11	16
export	153,356	11	14	17	7	7	57	56
Invoice currency for exports								
IEP, EUR	65,691	10	11	14	6	5	10	11
STG	49,535	11	17	19	9	8	99	100
US$	17,084	12	17	21	10	10	100	100
pre-EUR EU	10,941	12	14	16	7	7	100	100
post-EUR EU	6,882	5	8	10	4	4	12	16
other	3,223	15	17	19	9	7	100	100

Weighted by plant turnover in home, export market as appropriate. Equal weighting for within-plant-market quotes.

Table 7: Mean adjustment frequency by type of good and size class (%)

	Obs	Denomin. Currency					Home Currency	
		unw	wgt	wgt, adj. for exit	wgt inc	wgt dec	unw	wgt
Type of product (Vermeulen et al., 2007)								
cons food prod	78,097	14	14	16	10	4	24	25
cons non-food non-dur	38,729	5	6	9	4	2	25	57
cons durables	46,873	4	5	7	3	2	28	43
intermediates	205,055	13	16	18	8	8	26	38
energy	2,471	45	69	70	43	26	72	71
capital goods	71,328	7	12	17	6	6	33	63
Type of product (Rauch 1999)								
homogenous	23,995	28	47	48	26	20	40	57
reference priced	66,126	12	13	15	8	5	20	26
differentiated	196,337	10	15	17	8	7	28	46
unclassified	156,095	8	10	14	6	5	26	52
Size								
<20	60,112	8	23	25	14	9	14	32
20-49	115,124	10	20	22	11	9	23	30
50-249	205,110	10	17	18	11	6	29	33
250-500	35,529	19	11	13	6	5	45	38
500+	26,678	12	14	18	8	7	40	54

Weighted by plant turnover in home, export market as appropriate. Equal weighting for within-plant-market quotes.

Table 8: Size of price changes in currency of denomination, weighted - by export status, currency, type of product and size of firm

	Increases				Decreases			
	Mean	p25	p50	p75	Mean	p25	p50	p75
total	5.80	1.43	3.11	6.70	-5.39	-7.18	-3.30	-1.43
Destination market								
home	5.03	1.53	3.03	5.87	-5.00	-6.44	-3.00	-1.25
export	6.59	1.35	3.30	7.55	-5.58	-7.41	-3.41	-1.54
Invoice currency for exports								
IEP,EUR	6.06	1.77	3.51	6.90	-5.64	-7.27	-3.18	-2.00
STG	4.57	1.12	2.73	5.45	-4.21	-5.41	-2.44	-0.62
US $	9.34	1.41	4.99	11.48	-6.81	-8.83	-5.22	-2.04
pre-EUR EU	4.94	0.01	1.22	4.55	-3.97	-5.62	-1.69	-0.02
post-EUR EU	5.56	0.58	3.92	7.14	-4.83	-5.46	-2.74	-0.64
other	3.62	0.01	1.70	5.97	-4.31	-5.04	-0.69	-0.01
Type of product (Vermeulen et al., 2007)								
cons food prod	4.95	1.48	2.86	5.27	-5.86	-7.53	-3.80	-1.56
cons non-food non-durab	8.17	0.01	0.67	7.91	-4.71	-6.45	-0.02	-0.01
cons durables	9.69	2.66	5.00	10.00	-6.62	-9.96	-4.23	-1.50
intermediates	4.94	1.22	2.94	5.71	-4.06	-5.39	-2.64	-1.12
energy	8.58	3.72	7.23	11.48	-7.77	-10.60	-5.77	-2.83
capital goods	8.68	1.82	4.32	9.96	-7.97	-9.52	-6.06	-2.86
Type of product (Rauch, 1999)								
organized exchange	8.26	2.96	6.03	10.81	-7.59	-10.35	-5.28	-2.62
reference priced	5.04	1.54	2.72	5.04	-4.38	-5.46	-3.00	-1.84
differentiated	5.66	1.07	3.09	7.69	-5.29	-7.65	-3.11	-0.85
unclassified	5.61	1.01	2.79	5.74	-5.34	-6.62	-2.93	-0.94
Size								
<20	3.49	1.00	2.13	4.17	-3.46	-4.94	-1.93	-0.70
20-49	4.62	1.34	2.82	5.21	-3.71	-4.54	-2.38	-1.07
50-249	5.93	1.47	3.44	7.19	-5.77	-7.69	-3.71	-1.51
250-500	5.63	1.46	2.96	6.30	-4.37	-5.46	-2.73	-1.06
500+	6.23	1.42	3.15	6.95	-6.44	-8.23	-4.27	-1.97

Table 9: Extensive margin of price adjustment: Demand shocks - Probability of a Price Increase

	$\Delta_{t-s(t)} \ln e_{uk,t}$		λ_{uk}		Ps	χ^2 (p-val)	N	#	#
	coeff.	s.e.	coeff.	s.e.	R^2			f.e.	clust
total	25.40	(6.53)**	0.04	(0.13)	0.01	16.08 (0.00)	17,917	3,864	489
Type of product (Vermeulen et al., 2007)									
cons food prod	8.66	(8.67)	0.41	(0.32)	0.01	1.97 (0.37)	3,159	806	103
cons n-food n-durab	35.54	(27.77)	-0.99	(1.02)	0.03	3.83 (0.15)	525	158	52
cons durab	25.28	(19.29)	-0.92	(0.47)**	0.02	4.68 (0.10)	969	167	49
intermediates	34.54	(9.15)**	-0.06	(0.13)	0.01	14.24 (0.00)	10,983	2,343	224
capital goods	35.10	(14.64)**	-0.10	(0.19)	0.05	77.49 (0.00)	2,239	369	64
Type of product (Rauch, 1999)									
org. exchange	25.17	(12.91)**	0.52	(0.33)	0.03	5.00 (0.08)	1,967	539	44
reference priced	26.28	(12.15)**	-0.10	(0.21)	0.01	5.07 (0.08)	2,668	482	71
differentiated	32.82	(10.46)**	-0.02	(0.16)	0.02	25.02 (0.00)	9,699	2,041	229
Size									
<20	1.40	(20.93)	0.90	(0.45)**	0.01	4.01 (0.13)	1,203	343	88
20-29	27.11	(6.51)**	-0.50	(0.29)*	0.01	17.37 (0.00)	6,021	1,202	153
50-249	22.76	(6.24)**	-0.12	(0.11)	0.01	17.54 (0.00)	6,616	1,360	205
250-499	22.75	(19.87)	-0.10	(0.42)	0.01	1.93 (0.38)	2,884	689	25
500+	40.26	(3.99)**	0.47	(0.37)	0.04	160.25 (0.00)	1,193	270	18
Quartiles of share of imported materials in materials and wage bill									
Q1	15.94	(7.59)**	0.48	(0.39)	0.00	4.76 (0.09)	6,453	1,531	140
Q2	17.05	(13.52)	-0.06	(0.44)	0.01	2.04 (0.36)	2,368	552	151
Q3	22.86	(10.68)**	-0.54	(0.28)*	0.02	7.24 (0.03)	2,069	413	134
Q4	36.94	(9.69)**	-0.01	(0.11)	0.04	28.10 (0.00)	3,503	700	112
Ownership									
domestic	27.51	(8.78)**	0.12	(0.22)	0.01	9.81 (0.01)	14,872	3,238	382
foreign	22.18	(8.91)**	-0.04	(0.12)	0.01	10.69 (0.00)	3,045	626	113

Dependent variable is indicator for price increase in currency of denomination. Full set of plant-product-month-age of price fixed effects is included. Observations are weighted by turnover. Standard errors are clustered at the firm level. Two stars indicates significantly different from zero at the 5% level, one star indicates significantly different from zero at the 10% level.

Table 10: Extensive margin of price adjustment: Demand shocks - Probability of a Price Decrease

	$\Delta_{t-s(t)} \ln e_{uk,t}$		λ_{uk}		Ps	χ^2 (p-val)	N	#	#
	coeff.	s.e.	coeff.	s.e.	R^2			f.e.	clust
total	-29.74	(5.96)**	0.15	(0.11)	0.01	30.02 (0.00)	15,264	3,317	379
Type of product (Vermeulen et al., 2007)									
cons food prod	-30.04	(6.25)**	0.64	(0.17)**	0.03	27.17 (0.00)	2,528	658	78
cons n-food n-durab	-97.64	(78.62)	2.13	(1.22)*	0.03	5.17 (0.08)	291	93	35
cons durab	-10.74	(5.78)**	1.15	(0.87)	0.01	3.46 (0.18)	391	65	28
intermediates	-26.01	(8.13)**	-0.09	(0.11)	0.01	10.26 (0.01)	10,173	2,199	186
capital goods	-36.46	(15.72)**	0.01	(0.25)	0.05	38.25 (0.00)	1,838	281	52
Type of product (Rauch, 1999)									
org. exchange	-27.24	(6.89)**	0.63	(0.17)**	0.03	20.26 (0.00)	1,890	511	39
reference priced	-20.11	(10.72)**	0.10	(0.14)	0.01	9.83 (0.01)	2,009	356	55
differentiated	-36.09	(12.47)**	-0.03	(0.20)	0.02	46.14 (0.00)	8,670	1829	168
Size									
<20	-23.50	(9.01)**	2.17	(0.84)**	0.06	6.86 (0.03)	814	255	63
20-29	-15.63	(10.87)	-0.40	(0.25)	0.00	2.86 (0.24)	5,464	1,050	119
50-249	-25.90	(5.30)**	0.25	(0.11)**	0.02	39.74 (0.00)	5,306	1,130	166
250-499	-75.84	(21.75)**	-0.18	(0.60)	0.04	51.81 (0.00)	2,752	663	22
500+	-18.98	(11.60)	0.23	(0.28)	0.01	28.58 (0.00)	928	219	9
Quartiles of share of imported materials in materials and wage bill									
Q1	-26.56	(10.37)**	0.45	(0.16)**	0.01	7.75 (0.02)	5,757	1386	106
Q2	-27.94	(11.27)**	0.17	(0.31)**	0.02	11.38 (0.00)	1,711	385	105
Q3	-44.25	(11.94)**	0.40	(0.18)**	0.06	22.57 (0.00)	1,442	305	96
Q4	-28.89	(9.16)**	-0.07	(0.12)	0.03	17.96 (0.00)	3,118	621	104
Ownership									
domestic	-35.14	(7.95)**	0.27	(0.20)	0.01	37.09 (0.00)	12,868	2,816	296
foreign	-23.41	(6.50)**	0.03	(0.09)	0.02	15.35 (0.00)	2,396	501	88

Dependent variable is indicator for price increase in currency of denomination. Full set of plant-product-month-age of price fixed effects is included. Observations are weighted by turnover. Standard errors are clustered at the firm level. Two stars indicates significantly different from zero at the 5% level, one star indicates significantly different from zero at the 10% level.

Table 11: Extensive margin of price adjustment: Cost shocks - Probability of a Price Increase

	$\Delta_{t-s(t)} \ln z_t^i$ coeff.	s.e.	Pseudo R^2	χ^2 (p-val)	N	# f.e.	# clusters
total	3.33	(18.61)	0.00	0.03 (0.86)	16,797	2,627	329
Type of product (Vermeulen et al., 2007)							
cons food prod	-107.61	(10.46)**	0.01	105.80 (0.00)	2,700	530	61
cons n-food n-durab	182.85	(75.84)**	0.10	5.81 (0.02)	402	118	42
cons durab	103.91	(84.79)	0.01	1.50 (0.22)	878	134	30
intermediates	21.67	(3.07)**	0.00	49.82 (0.00)	11,215	1,558	148
capital goods	56.86	(58.23)	0.00	0.95 (0.33)	1,589	281	54
Type of product (Rauch, 1999)							
organized exchange	-155.38	(409.51)	0.00	0.14 (0.70)	1,336	299	16
reference priced	0.07	(21.80)	0.00	0.00 (1.00)	4,363	371	39
differentiated	96.66	(91.22)	0.00	1.12 (0.29)	7,865	1377	168
Size							
<20	147.70	(47.99)**	0.02	9.47 (0.00)	1,021	250	70
20-29	-29.20	(7.55)**	0.00	14.95 (0.00)	5,356	966	118
50-249	4.47	(41.24)	0.00	0.01 (0.91)	4,876	887	152
250-499	0.00	(0.01)	0.01	0.00 (0.00)	1,690	397	24
500+	238.80	(88.36)**	0.01	7.30 (0.01)	427	111	23
Ownership							
domestic	20.08	(1.12)**	0.00	319.85 (0.00)	13,809	2,162	258
foreign	-92.65	(24.27)**	0.01	14.57 (0.00)	2,318	441	88

Dependent variable is indicator for a price decrease in currency of denomination. Full set of product-market-month-age of price fixed effects is included. Observations are weighted by turnover. Standard errors are clustered at the firm level. Two stars indicates significantly different from zero at the 5% level.

Table 12: Extensive margin of price adjustment: Cost shocks - Probability of a Price Decrease

	$\Delta_{t-s(t)} \ln z_t^i$ coeff.	s.e.	Pseudo R^2	χ^2 (p-val)	N	# f.e.	# clusters
total	-24.19	(7.74)**	0.00	9.76 (0.00)	13,635	2,149	247
Type of product (Vermeulen et al., 2007)							
cons food prod	-461.90	(243.19)*	0.01	3.61 (0.06)	1,945	419	51
cons n-food n-durab	-1278.15	(830.90)	0.04	2.37 (0.12)	189	62	27
cons durab	11.52	(126.88)	0.00	0.01 (0.93)	172	40	16
intermediates	-21.36	(6.04)**	0.00	12.52 (0.00)	10,114	1,428	117
capital goods	16.68	(66.42)	0.00	0.06 (0.80)	1,207	197	36
Type of product (Rauch, 1999)							
organized exchange	-169.90	(253.78)	0.00	0.45 (0.50)	1,376	314	19
reference priced	-20.16	(4.09)**	0.00	24.30 (0.00)	3,039	204	29
differentiated	-60.36	(40.35)	0.00	2.24 (0.13)	7,022	1,221	113
Size							
<20	-531.59	(373.21)	0.07	2.03 (0.15)	743	194	48
20-29	-5.08	(2.10)**	0.00	5.82 (0.02)	4,648	820	87
50-249	-49.82	(15.95)**	0.00	9.75 (0.00)	3,694	727	115
250-499	-0.00	(0.00)	0.00	0.00 (0.00)	1,568	370	21
500+	-7389.59	(13162.55)	0.06	0.32 (0.57)	298	99	11
Ownership							
domestic	-19.59	(4.55)**	0.00	18.54 (0.00)	11,603	1,803	195
foreign	-306.74	(105.86)**	0.03	8.40 (0.00)	1,497	346	61

Dependent variable is indicator for a price decrease in currency of denomination. Full set of product-market-month-age of price fixed effects is included. Observations are weighted by turnover. Standard errors are clustered at the firm level. Two stars indicates significantly different from zero at the 5% level.

Table 13: Intensive margin of price adjustment: Demand shocks - No asymmetry, by type of product

	$\Delta_{t-s(t)}$ $\ln e_t\,(uk)$	UK dummy	cons-tant	R^2 adj	N	# f.e.	# clusters
total	0.99	-0.00	0.02	0.86	32,713	14,492	634
	(0.08)**	(0.00)	(0.00)**				
Type of product (Vermeulen et al., 2007)							
cons food prod	0.89	0.00	0.03	0.87	7,033	3,974	133
	(0.17)**	(0.01)	(0.00)**				
cons n-food n-durab	2.51	-0.07	0.06	0.87	1,011	664	68
	(0.46)**	(0.03)**	(0.01)**				
cons durab	1.10	-0.01	0.06	0.92	1,098	466	60
	(0.16)**	(0.00)**	(0.00)**				
intermediates	1.05	-0.00	0.01	0.83	20,126	8,106	290
	(0.20)**	(0.00)	(0.00)**				
capital goods	1.04	0.00	0.01	0.78	3,182	1,095	90
	(0.08)**	(0.00)	(0.00)**				
Type of product (Rauch, 1999)							
organized exchange	0.96	0.00	-0.00	0.75	3,974	2,296	55
	(0.40)**	(0.01)	(0.00)				
reference priced	0.96	-0.01	0.03	0.98	5,660	2,205	85
	(0.12)**	(0.01)*	(0.00)**				
differentiated	1.14	0.00	0.01	0.76	15,089	6,205	299
	(0.14)**	(0.00)	(0.00)**				

Dependent variable is log change in home currency price since s(t). Standard errors in brackets below coefficient. Full set of plant-product-month-age of price fixed effects is included. Observations are weighted by turnover. Standard errors are clustered at the firm level. Two stars indicates significantly different from zero at the 5% level, one star indicates significantly different from zero at the 10% level.

Table 14: Intensive margin of price adjustment: Demand shocks - No asymmetry, Conditional on all prices in the group, by size changing, share of imported intermediates and ownership

	$\Delta_{t-s(t)}$ $\ln e_t\,(uk)$	UK dummy	cons- tant	R^2 adj	N	# f.e.	# clusters
total	0.99	-0.00	0.02	0.86	32,713	14,492	634
	(0.08)**	(0.00)	(0.00)**				
Size							
<20	1.22	0.00	0.01	0.94	3,443	1,706	121
	(0.11)**	(0.01)	(0.00)**				
20-29	0.98	-0.01	0.01	0.87	10,498	4,084	196
	(0.17)**	(0.00)**	(0.00)**				
50-249	1.05	-0.00	0.02	0.90	12,307	5,869	267
	(0.11)**	(0.00)	(0.00)**				
250-499	1.07	-0.00	0.02	0.69	4,641	1,860	34
	(0.06)**	(0.00)	(0.00)**				
500+	0.07	0.01	0.01	0.89	1,824	973	16
	(0.08)	(0.00)**	(0.00)**				
Quartiles of share of imported materials in materials and wage bill							
Q1	0.71	0.00	0.01	0.77	11,202	4,968	208
	(0.40)*	(0.01)	(0.00)**				
Q2	1.03	-0.02	0.03	0.95	4,430	2,313	227
	(0.10)**	(0.01)*	(0.00)**				
Q3	1.09	-0.00	0.04	0.95	3,604	1,664	195
	(0.15)**	(0.01)	(0.00)**				
Q4	1.05	-0.00	0.01	0.92	7,329	3,136	158
	(0.14)**	(0.00)	(0.00)**				
Ownership							
domestic	1.03	-0.00	0.01	0.81	25,936	11,691	504
	(0.11)**	(0.00)	(0.00)**				
foreign	0.91	-0.00	0.03	0.95	6,777	2,801	146
	(0.09)**	(0.00)	(0.00)**				

Dependent variable is log change in home currency price since s(t). Standard errors in brackets below coefficient. Full set of plant-product-month-age of price fixed effects is included. Observations are weighted by turnover. Standard errors are clustered at the firm level. Two stars indicates significantly different from zero at the 5% level, one star indicates significantly different from zero at the 10% level.

Table 15: Intensive margin of price adjustment: Demand shocks - Asymmetry, Conditional on all prices in the group changing, by type of product

	$\Delta_{t-s(t)}$ $\ln e_t^+ (uk)$	$\Delta_{t-s(t)}$ $\ln e_t^- (uk)$	UK dummy	cons-tant	R^2 adj	N	# f.e.	# clusters
total	1.06	0.82	-0.00	0.02	0.86	32,713	14,492	634
	(0.09)**	(0.25)**	(0.00)	(0.00)**				
Type of product (Vermeulen et al., 2007)								
cons food prod	1.01	0.47	-0.00	0.03	0.87	7,033	3,974	133
	(0.06)**	(0.75)	(0.01)	(0.00)**				
cons n-food n-durab	1.96	4.26	-0.03	0.05	0.87	1,011	664	68
	(0.35)**	(1.03)**	(0.02)*	(0.00)**				
cons durab	1.21	0.64	-0.02	0.06	0.92	1,098	466	60
	(0.15)**	(0.18)**	(0.00)**	(0.00)**				
intermediates	1.29	0.65	-0.01	0.01	0.83	20,126	8,106	290
	(0.33)**	(0.30)**	(0.00)**	(0.00)**				
capital goods	0.94	1.24	0.00	0.01	0.78	3,182	1,095	90
	(0.12)**	(0.08)**	(0.00)	(0.00)**				
Type of product (Rauch, 1999)								
organized exchange	1.21	0.61	0.00	-0.00	0.75	3,974	2,296	55
	(0.20)**	(0.95)	(0.01)	(0.00)				
reference priced	1.14	0.37	-0.02	0.03	0.98	5,660	2,205	85
	(0.09)**	(0.26)	(0.01)**	(0.00)**				
differentiated	1.12	1.18	0.00	0.01	0.76	15,089	6,205	299
	(0.20)**	(0.19)**	(0.00)	(0.00)**				

Dependent variable is log change in home currency price since s(t). Standard errors in brackets below coefficient. Full set of plant-product-month-age of price fixed effects is included. Observations are weighted by turnover. Standard errors are clustered at the firm level. Two stars indicates significantly different from zero at the 5% level, one star indicates significantly different from zero at the 10% level.

Table 16: Intensive margin of price adjustment: Demand shocks - Asymmetry, Conditional on all prices in the group changing, by size, share of imported intermediates and ownership

	$\Delta_{t-s(t)}$ $\ln e_t^+ \ (uk)$	$\Delta_{t-s(t)}$ $\ln e_t^- \ (uk)$	UK dummy	cons-tant	R^2 adj	N	# f.e.	# clusters
total	1.06	0.82	-0.00	0.02	0.86	32,713	14,492	634
	(0.09)**	(0.25)**	(0.00)	(0.00)**				
Size								
<20	1.48	1.03	-0.00	0.01	0.94	3,443	1,706	121
	(0.31)**	(0.22)**	(0.01)	(0.00)**				
20-29	0.89	1.08	-0.01	0.01	0.87	10,498	4,084	196
	(0.25)**	(0.21)**	(0.00)**	(0.00)**				
50-249	1.04	1.08	-0.00	0.02	0.90	12,307	5,869	267
	(0.10)**	(0.37)**	(0.01)	(0.00)**				
250-499	1.15	0.94	-0.00	0.02	0.69	4,641	1,860	34
	(0.22)**	(0.32)**	(0.01)	(0.00)**				
500+	1.11	-1.18	-0.01	0.01	0.89	1,824	973	16
	(0.13)**	(0.17)**	(0.00)**	(0.00)**				
Quartiles of share of imported materials in materials and wage bill								
Q1	1.34	0.07	-0.00	0.01	0.77	11,202	4,968	208
	(0.34)**	(1.13)	(0.00)*	(0.00)**				
Q2	1.15	0.49	-0.02	0.03	0.95	4,430	2,313	227
	(0.10)**	(0.50)	(0.01)*	(0.00)**				
Q3	1.40	0.66	-0.01	0.04	0.95	3,604	1,664	195
	(0.33)**	(0.34)*	(0.01)	(0.00)**				
Q4	1.00	1.14	0.00	0.01	0.92	7,329	3,136	158
	(0.18)**	(0.15)**	(0.00)	(0.00)**				
Ownership								
domestic	1.15	0.82	-0.00	0.01	0.81	25,936	11,691	504
	(0.14)**	(0.29)**	(0.00)	(0.00)**				
foreign	0.95	0.72	-0.00	0.03	0.95	6,777	2,801	146
	(0.11)**	(0.23)**	(0.00)	(0.00)**				

Dependent variable is log change in home currency price since s(t). Standard errors in brackets below coefficient. Full set of plant-product-month-age of price fixed effects is included. Observations are weighted by turnover. Standard errors are clustered at the firm level. Two stars indicates significantly different from zero at the 5% level, one star indicates significantly different from zero at the 10% level.

Table 17: Intensive margin of price adjustment: Cost shocks - Conditional all prices in the group changing

No Asymmetry	$\Delta_{t-s(t)}$ $\ln z_t^i$		cons-tant	R^2 adj	N	# f.e.	# clusters
total	-0.02		0.03	0.87	21,924	8,880	515
	(0.04)		(0.00)**				
Asymmetry	$\Delta_{t-s(t)}$ $\ln z_t^{i+}$	$\Delta_{t-s(t)}$ $\ln z_t^{i-}$	**cons-tant**	R^2 **adj**	**N**	**# f.e.**	**# clusters**
total	-0.09	0.07	0.03	0.87	21,924	8,880	515
	(0.07)	(0.07)	(0.00)**				

Dependent variable is log change in home currency price since s(t). Standard errors in brackets below coefficient. Full set of product-market-month-age of price fixed effects is included. Observations are weighted by turnover. Standard errors are clustered at the firm level. Two stars indicates significantly different from zero at the 5% level.

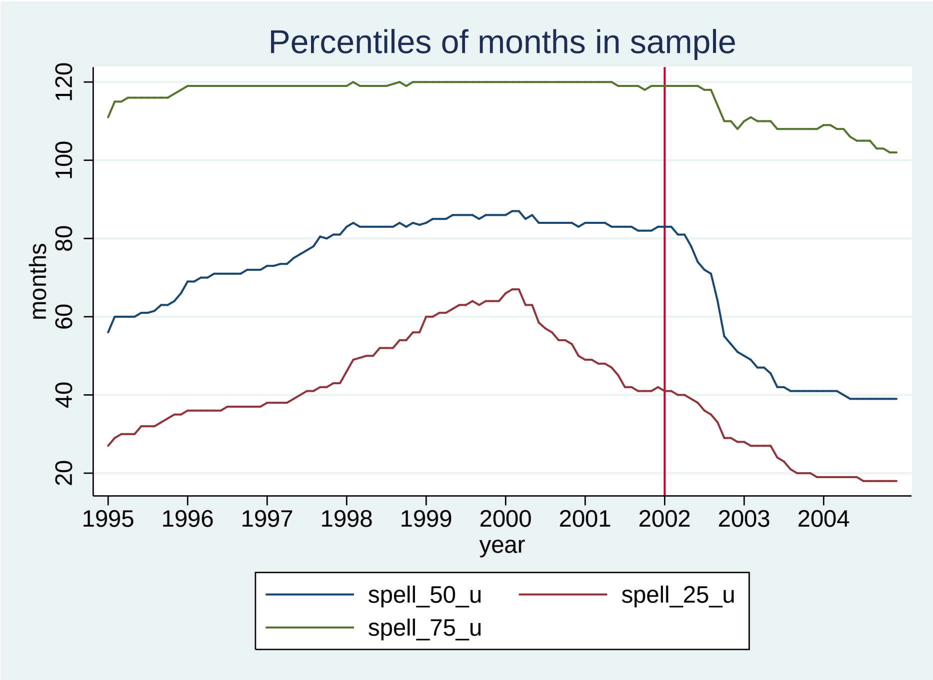

Figure 1: Percentiles of distribution of length of time we observe price quotes

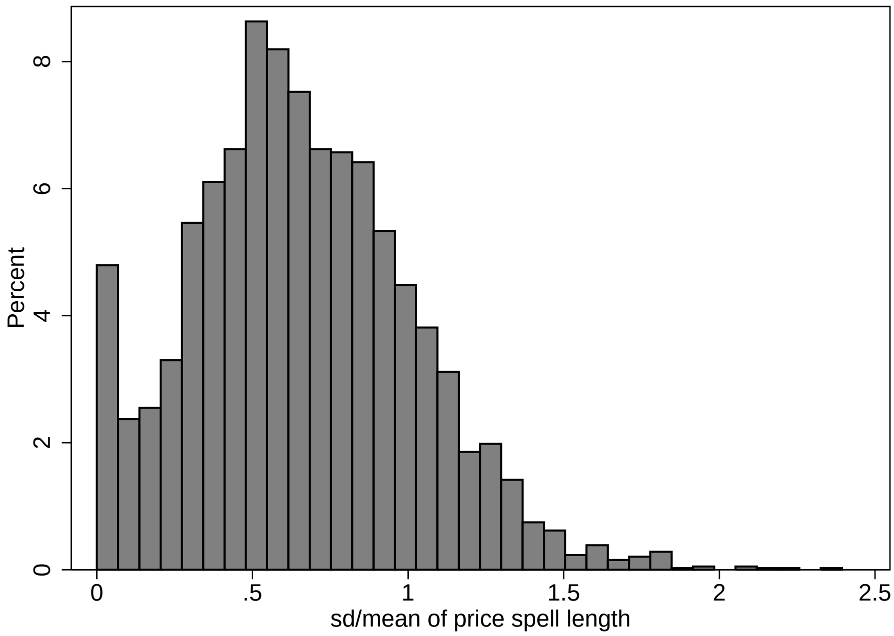

Figure 2: Standard deviation relative to the mean of the length of price spells

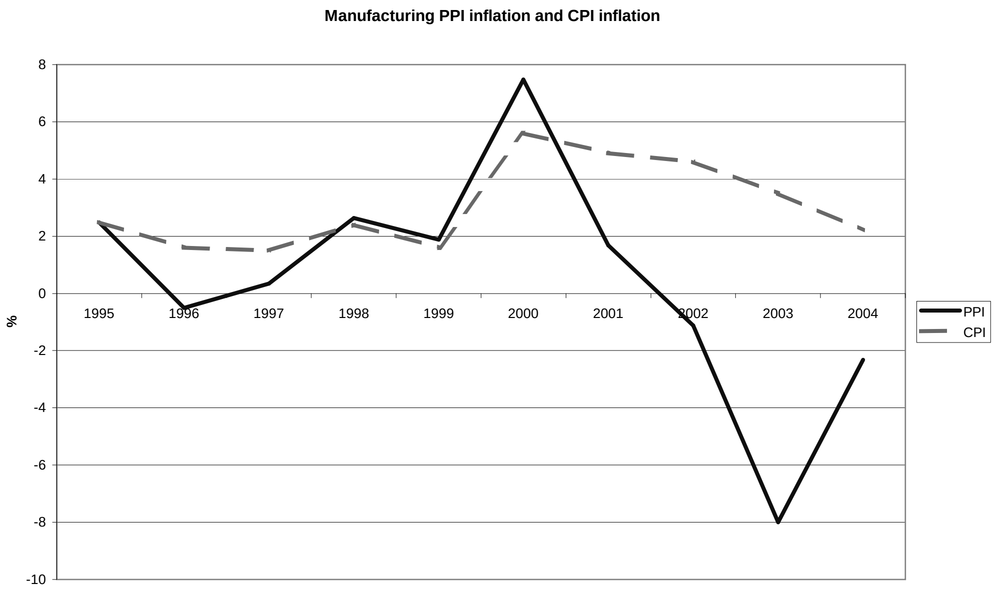

Figure 3: Manufacturing PPI inflation and CPI inflation over the sample period

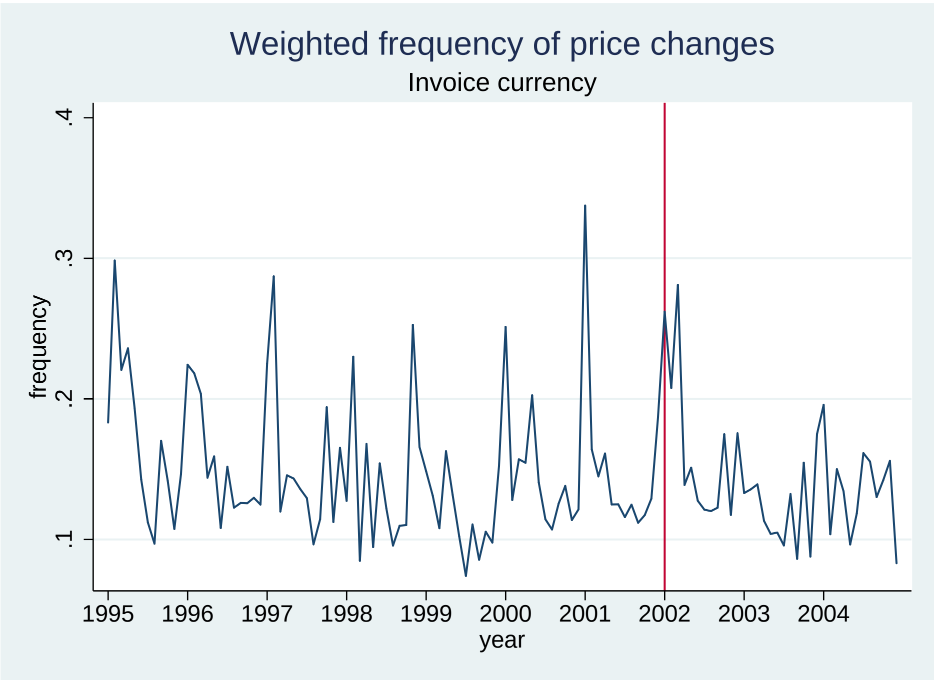

Figure 4: Weighted frequency of price changes measured in invoice currency, month-by-month

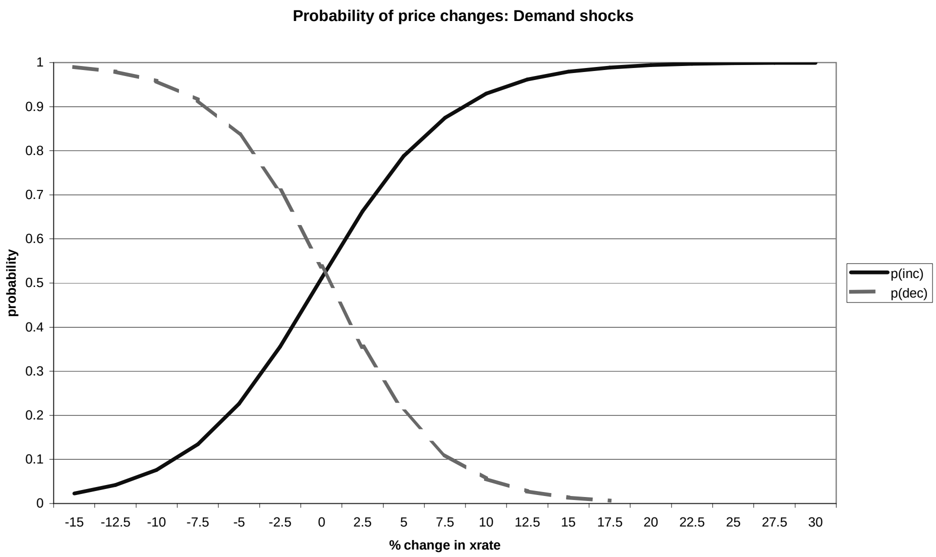

Figure 5: Predicted probability of price increases and decreases given demand shocks

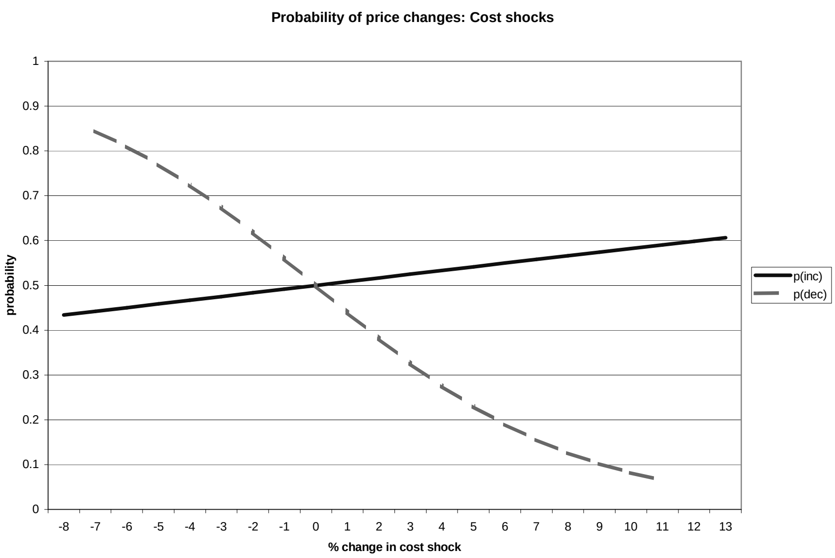

Figure 6: Predicted probability of price increases and decreases given cost shocks

A Appendix

Additional Information on the Data from the Census of Industrial Production

While data on the *turnover* of local units is collected by the CSO, it is not reported in the official publication of the Census of Industrial Production. In some cases the entry for turnover is zero, but the entry for gross output is positive. In these cases plant turnover is calculated in reverse as Turnover from goods produced and industrial services = Gross output + Freight charges for transport of the enterprise's products - Operating subsidies + Excise duty paid or payable on goods produced by the enterprise - End of year stock of work in progress and finished goods + Beginning of year stock of work in progress and finished goods - Value of capitalized work performed by the enterprise for its own use. Figures on *employment* relate to employment in a local unit in the second week of September. In some cases this can result in zero employees in combination with a positive wage bill. Where the average wage is clearly out of line with the local unit's employment history, the figures are adjusted. Once-off changes in *ownership* or *NACE classification* that revert in the following year are ignored. The *share of turnover exported* is cleaned from values smaller than zero and values larger than 100 using information from previous and/or later years of the observation in question. From 2001 companies are not only asked for the share of turnover they export but also for the value of their exports. Comparing these two figures where available suggests that information based on the share of turnover exported overestimates the true figures by 1-2 percentage points per year on average. From 2001 the share of turnover exported is calculated from the value figures where possible, information based on the 'share of turnover exported' question is, however, more comprehensive. In years where some of the information for a local unit is imputed or the entire observation is estimated information on exports is adjusted to relate to earlier or later non-imputed/estimated information for the plant rather than to industry averages. Information on the destination of exports is adjusted to match the figures on the share of turnover exported. Information on the *share of imported materials* has been collected for the local units from 2001 only. However, the question has been asked of the enterprises since 1994. As 90% of the local units in Ireland are single-plant firms they are enterprises at the same time. We use the information for these plants from the enterprise files. This data as well as the source country information undergoes checking similar to the export information. The routine for checking this information has been changed by the CSO from 2000 to 2001. From 2001 the figures are only checked if the company purchased inputs in excess of 1 Million Euro. This leads to significant changes in the shares of imported materials for some of the plants with total purchases of inputs of less than 1 Million Euro, in some cases so extreme that we decide not to use this information; in other cases adjustments are made in line with the data collected up to 2000.

Additional Information on the PPI Data

New entrants to the PPI survey are asked to fill out a detailed form. They are asked to provide price series for their main products, partially or fully manufactured in Ireland. Both home market prices and export prices (where relevant) are specifically requested. Respondents are asked to give an approximate breakdown of the relative importance of the different items in sales at the time of entrance to the survey (this information is not systematically supplied by all respondents). They are asked for a detailed description of the included products, by providing pictures or brochures and tariff codes, where possible. Information on "trading terms" (type of customer, order size, delivery terms, discount procedure, currency surcharges etc.) is requested. This variable is not systematically coded. New respondents are also asked to provide information on the country of sale. The form supplied to them has explicitly labeled spaces for home sales and export sales, and whether a price refers to a home or export sale is systematically recorded in the data provided to us. However the destination country is often not provided for export sales, and there is no systematic coding of this variable. Prices provided should be those invoiced for the product on the 15th of the month, excluding value added taxes, before discounts and surcharges are applied, net of direct subsidies (where applicable) and excluding excise duty. There is a space on the form for discounts and surcharges to be reported. Transfer prices are specifically to be excluded from the survey. There are additional spaces on the initial form for respondents to report the currency in which the price is quoted and the relevant units. Continuing respondents are provided with a form where the product description and terms of sale are already filled in. They are asked to report the new price and relevant discount/surcharge. They are asked to state the reason for price changes. Responses to this question are not provided to us. If there has been a change to the trading terms, they should be reported, and coded as the exit of one item quote and the entry of a new item quote. Given the long length of price spells, it is not clear that continuing participants do indeed report such changes. In the form that it reaches us, we have a plant identifier, a product identifier (across firms, at a sub-NACE 4-digit level, but not exactly lined up with PRODCOM), an item identifier (at a more detailed level of disaggregation than the product identifier, again not exactly lined up with PRODCOM) and for some observations, a within-plant weighting variable that does not change over time. For each item in the sample, we have monthly information on the price (in a format to be described), the invoice currency and whether the item is a domestic sale or an export sale. For observations that are present in the last cross-section available to us (November 2006), if respondents fill in these fields, we have the trading terms and destination country. The price data are presented already converted into Irish pounds (both pre and post introduction of the Euro as a currency on 1st January 2002). The exchange rate used to make the conversion from foreign currency (daily rate from the 15th of the month) is included with the data. The conversion from Euros is made at the fixed Euro conversion rate. There are two formats for prices: the Irish pound price, and the ”price relative” or ratio of the Irish pound price in the current month to the Irish pound price in the previous month. There are no gaps in the Irish pound price series. That is, if a particular price quote is available at date t and at date t+k, it is available at all dates in between. However there are gaps in the price relative series where the CSO deemed there to be problems with the reported Irish pound price. All of the empirical work is based on the data as presented in price relative form. The ratio of the original currency price in the current month to the original currency price in the previous month is calculated using the price relative and the exchange rate series provided with the data. A rounding rule is used to select observations for which there is no change in the original currency price from month to month.

NACE 3-digit industries in 6 groups based on Vermeulen et al. (2007)[6]

I. Consumer food products 151 Production, processing and preserving of meat and meat products 152 Processing and preserving of fish and fish products 153 Processing and preserving of fruit and vegetables 154 Manufacture of vegetable and animal oils and fats 155 Manufacture of dairy products 158 Manufacture of other food products 159 Manufacture of beverages 160 Manufacture of tobacco products **II. Consumer non- food non-durables**

[6] Includes only industries where firms are recorded to be in production in Ireland

174 Manufacture of made-up textile articles, except apparel 175 Manufacture of other textiles 177 Manufacture of knitted and crocheted articles 181 Manufacture of leather clothes 182 Manufacture of other wearing apparel and accessories 183 Dressing and dyeing of fur; manufacture of articles of fur 191 Tanning and dressing of leather 192 Manufacture of luggage, handbags and the like, saddlery and harness 193 Manufacture of footwear 221 Publishing 222 Printing and service activities related to printing 223 Reproduction of recorded media 244 Manufacture of pharmaceuticals, medicinal chemicals and botanical products 245 Manufacture of soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations 364 Manufacture of sports goods 365 Manufacture of games and toys 366 Miscellaneous manufacturing n.e.c. **III. Consumer durables** 297 Manufacture of domestic appliances n.e.c. 323 Manufacture of television and radio receivers, sound or video recording or reproducing apparatus and associated goods 334 Manufacture of optical instruments and photographic equipment 335 Manufacture of watches and clocks 341 Manufacture of motor vehicles 354 Manufacture of motorcycles and bicycles 361 Manufacture of furniture 362 Manufacture of jewelery and related articles 363 Manufacture of musical instruments **IV. Intermediate goods** 132 Mining of non-ferrous metal ores, except uranium and thorium ores 141 Quarrying of stone 142 Quarrying of sand and clay 143 Mining of chemical and fertilizer minerals 145 Other mining and quarrying n.e.c. 156 Manufacture of grain mill products, starches and starch products 157 Manufacture of prepared animal feeds 171 Preparation and spinning of textile fibres 172 Textile weaving 173 Finishing of textiles 176 Manufacture of knitted and crocheted fabrics 201 Sawmilling and planing of wood; impregnation of wood 202 Manufacture of veneer sheets; manufacture of plywood, laminboard, particle board, fibre board and other panels and boards 203 Manufacture of builders' carpentry and joinery 204 Manufacture of wooden containers 205 Manufacture of other products of wood; manufacture of articles of cork, straw and plaiting materials 211 Manufacture of pulp, paper and paperboard 212 Manufacture of articles of paper and paperboard 241 Manufacture of basic chemicals 242 Manufacture of pesticides and other agro-chemical products 243 Manufacture of paints, varnishes and similar coatings, printing ink and mastics 246 Manufacture of other chemical products 247 Manufacture of man-made fibres 251 Manufacture of rubber products 252 Manufacture of plastic products 261 Manufacture of glass and glass products 262 Manufacture of non-refractory ceramic goods other than for construction purposes; manufacture of refractory ceramic products 263 Manufacture of ceramic tiles and flags 264 Manufacture

of bricks, tiles and construction products, in baked clay 265 Manufacture of cement, lime and plaster 266 Manufacture of articles of concrete, plaster and cement 267 Cutting, shaping and finishing of ornamental and building stone 268 Manufacture of other non-metallic mineral products 271 Manufacture of basic iron and steel and of ferro-alloys 272 Manufacture of tubes 273 Other first processing of iron and steel 274 Manufacture of basic precious and non-ferrous metals 275 Casting of metals 284 Forging, pressing, stamping and roll forming of metal; powder metallurgy 285 Treatment and coating of metals; general mechanical engineering 286 Manufacture of cutlery, tools and general hardware 287 Manufacture of other fabricated metal products 312 Manufacture of electricity distribution and control apparatus 313 Manufacture of insulated wire and cable 314 Manufacture of accumulators, primary cells and primary batteries 315 Manufacture of lighting equipment and electric lamps 316 Manufacture of electrical equipment n.e.c. 321 Manufacture of electronic valves and tubes and other electronic components **V. Energy** 101 Mining and agglomeration of hard coal 102 Mining and agglomeration of lignite 103 Extraction and agglomeration of peat 111 Extraction of crude petroleum and natural gas 112 Service activities incidental to oil and gas extraction, excluding surveying 232 Manufacture of refined petroleum products !!! might drop these two, we don't include the plants from these sectors 401 Production and distribution of electricity 402 Manufacture of gas; distribution of gaseous fuels through mains **VI. Capital goods** 281 Manufacture of structural metal 282 Manufacture of tanks, reservoirs and containers of metal; manufacture of central heating radiators and boilers 283 Manufacture of steam generators, except central heating hot water boilers 291 Manufacture of machinery for the production and use of mechanical power, except aircraft, vehicle and cycle engines 292 Manufacture of other general purpose machinery 293 Manufacture of agricultural and forestry machinery 294 Manufacture of machine tools 295 Manufacture of other special purpose machinery 300 Manufacture of office machinery and computers 311 Manufacture of electric motors, generators and transformers 322 Manufacture of television and radio transmitters and apparatus for line telephony and line telegraphy 331 Manufacture of medical and surgical equipment and orthopaedic appliances 332 Manufacture of instruments and appliances for measuring, checking, testing, navigating and other purposes, except industrial process control 333 Manufacture of industrial process control equipment 342 Manufacture of bodies (coachwork) for motor vehicles; manufacture of trailers and semi-trailers 343 Manufacture of parts and accessories for motor vehicles and their engines 351 Building and repairing of ships and boats 352 Manufacture of railway and tramway locomotives and rolling stock 353 Manufacture of aircraft and spacecraft 355 Manufacture of other transport equipment n.e.c.

Rauch classification at the 2- to 4-digit NACE level

Homogenous 151 Production, processing and preserving of meat and meat products 154 Manufacture of vegetable and animal oils and fats 232 Manufacture of refined petroleum products **Reference priced** 132 Mining of non-ferrous metal ores, except uranium and thorium ores 152 Processing and preserving of fish and fish products 153 Processing and preserving of fruit and vegetables 155 Manufacture of dairy products 156 Manufacture of grain mill products, starches and starch products 157 Manufacture of prepared animal feeds 1583 Manufacture of sugar 1585 Manufacture of macaroni, noodles, couscous and similar farinaceous products 1586 Processing of tea and coffee 1587 Manufacture of condiments and seasonings 1588 Manufacture of homogenized food preparations and dietetic food 1589 Manufacture of other food products n.e.c. 1591 Manufacture of distilled potable alcoholic beverages 1594 Manufacture of cider and other fruit wines 1596 Manufacture of beer 1597 Manufacture of malt 16 Manufacture of tobacco products 1753 Manufacture of non-wovens and articles made from non-wovens, except apparel 1754 Manufacture of other textiles n.e.c. 2121 Manufacture of corrugated paper and paperboard and of containers of paper and paperboard 2411 Manufacture of industrial gases 2412 Manufacture of dyes and pigments 2413 Manufacture of other inorganic basic chemicals 2414 Manufacture of other organic basic chemicals 2415 Manufacture of fertilizers and nitrogen compounds 244 Manufacture of pharmaceuticals, medicinal chemicals and botanical products 247 Manufacture of man-made fibres 274 Manufacture of basic precious and non-ferrous metals 4011 Production of electricity 4013 Distribution and trade of electricity **Differentiated** 101 Mining and agglomeration of hard coal 111 Extraction of crude petroleum and natural gas 1411 Quarrying of ornamental and building stone 1412 Quarrying of limestone, gypsum and chalk 1421 Operation of gravel and sand pits 145 Other mining and quarrying n.e.c. 1581 Manufacture of bread; manufacture of fresh pastry goods and cakes 1582 Manufacture of rusks and biscuits; manufacture of preserved pastry goods and cakes 1598 Production of mineral waters and soft drinks 1751 Manufacture of carpets and rugs 1752 Manufacture of cordage, rope, twine and netting 176 Manufacture of knitted and crocheted fabrics 177 Manufacture of knitted and crocheted articles 18 Manufacture of wearing apparel; dressing and dyeing of fur 19 Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear 202 Manufacture of veneer sheets; manufacture of plywood, laminboard, particle board, fibre board and other panels and boards 203 Manufacture of builders' carpentry and joinery 204 Manufacture of wooden containers 205 Manufacture of other products of wood; manufacture of articles of cork, straw and plaiting materials 211 Manufacture of pulp, paper and paperboard 2122 Manufacture of household and sanitary goods and of toilet requisites 2123 Manufacture of paper stationery 2125 Manufacture of other articles of paper and paperboard n.e.c. 221 Publishing 222 Printing and service activities related to printing 2416 Manufacture of plastics in primary forms 242 Manufacture of pesticides and other agro-chemical products 243 Manufacture of paints, varnishes and similar coatings, printing ink and mastics 245 Manufacture of soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations 2511 Manufacture of rubber tyres and tubes 2512 Retreading and rebuilding of rubber tyres 252 Manufacture of plastic products 261 Manufacture of glass and glass products 2626 Manufacture of refractory ceramic products 263 Manufacture of ceramic tiles and flags 264 Manufacture of bricks, tiles and construction products, in baked clay 265 Manufacture of cement, lime and plaster 266 Manufacture of articles of concrete, plaster and cement 267 Cutting, shaping and finishing of ornamental and building stone 268 Manufacture of other non-metallic mineral products 281 Manufacture of structural metal products 282 Manufacture of tanks, reservoirs and containers of metal; manufacture of central heating radiators and boilers 286 Manufacture of cutlery, tools and general hardware 287 Manufacture of other fabricated metal products 29 Manufacture of machinery and equipment n.e.c. (except NACE 296) 311 Manufacture of electric motors, generators and transformers 313 Manufacture of insulated wire and cable 314 Manufacture of accumulators, primary cells and primary batteries 315 Manufacture of lighting equipment and electric lamps 316 Manufacture of electrical equipment n.e.c. 321 Manufacture of electronic valves and tubes and other electronic components 322 Manufacture of television and radio transmitters and apparatus for line telephony and line telegraphy 323 Manufacture of television and radio receivers, sound or video recording or reproducing apparatus and associated goods 331 Manufacture of medical and surgical equipment and orthopaedic appliances 332 Manufacture of instruments and appliances for measuring, checking, testing, navigating and other purposes, except industrial process control equipment 334 Manufacture of optical instruments and photographic equipment 335 Manufacture of watches and clocks 34 Manufacture of motor vehicles, trailers and semi-trailers 35 Manufacture of other transport equipment 36 Manufacture of furniture; manufacturing n.e.c.