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# Exchange Rates, Wages, and Export Price Dynamics

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# Abstract

In this paper, I investigate the effects on export prices (in the currency of the exporter) of shocks to the exchange rate, the exporting firms' costs and foreign prices. The theoretical analysis is done with alternative assumptions regarding the currency in which prices are set and the desired markup. After that, I use a VAR-framework to analyze which theory predicts actual outcome the best. The results indicate that export prices (in the currency of the exporter) respond strongly to exchange rate shocks and the effects seem to be in line with the theory of producer currency pricing and pricing to market. Wage shocks have insignificant effects.

**JEL classification code**: E31, F14, F31

Keywords: Vector autoregression, exchange rates, export prices, local currency pricing, producer currency pricing, pricing to the market

# Sammanfattning

I denna uppsats analyseras effekter av chocker i växelkurs, kostnader och utländska priser på exportpriser (i exportörers valuta). Den teoretiska analysen inkluderar olika antaganden beträffande valutan i vilken exportpriser sätts samt företagens pålägg på marginalkostnad. Efter den teoretiska analysen skattas en VAR-modell för att analysera vilken teori som stämmer ”bäst” överens med data. Resultaten visar på en stark respons av en växelkurschock på exportpriser (i exportörers valuta). Effekterna är i linje med teorin om producentprissättning (”Producer Currency Pricing”) och marknadsanpassad prissättning (”Pricing to the Market”). Chocker till löner har inga signifikanta effekter.

# 1 Introduction

The relation between prices and exchange rates has for a long time been an important research topic. The ability of the exchange rate to work as a stabilizer in open economies hinges on the assumption that movements in the exchange rates are passed on to import prices. Exchange rate pass-through (henceforth ERPT) is defined as the percentage change in local currency import prices following a one percent change in the exchange rate between the exporting and the importing country.[1] The size of the effect of monetary policy depends on how large the expenditure-switching effects are which, in turn, directly depends on the degree of ERPT. Further, the degree of ERPT affects current as well as expected inflation, implying a direct channel for monetary policy to affect the price level.[2] Thus, assessing the degree to which price changes respond to changes in exchange rates is important, especially so in countries with a high degree of openness.

ERPT is derived by modeling the price setting of exporting firms. Traditionally, in the macroeconomic literature, models with fixed markups and nominal price stickiness are assumed. These features are then combined with certain assumptions regarding the currency in which prices are set. Producer currency pricing (henceforth PCP) means that the exporting firm sets its price in its own currency. Then, we would have immediate and full ERPT of exchange rates to import prices. Local currency pricing (henceforth LCP) means that the price is set in the currency of the destination country. Then, the price on the import market is completely independent of the exchange rate in the short run and we have a gradual ERPT. Empirical studies have often rejected the extreme cases of PCP and LCP, thus implying that there is some pass-through but that it is 'partial' or 'incomplete'.

At the micro level, more static models of ERPT have been used. Here, the concept of pricing to the market (henceforth PTM) has gained much attention. PTM can occur when there is imperfect competition, so that exporters' have some market power, and markets are segmented, i.e. we have price discrimination. Then, exchange rate changes lead to changes in price discrimination across destination markets. According to Krugman (1986), PTM occurs when exporting firms increase their export prices measured in their own currency when there is an appreciation of the currency of the importing country. What this means is that import prices measured in the importing country's currency fall too little when a currency appreciates, i.e. there is incomplete pass-through. Further, if a firm sets the price according to PTM, this implies that exporters do not fully pass through changes in marginal costs since that would imply a competitive disadvantage for the exporting firm. This is shown graphically in Figure 1, which is similar to Figure 1 in Gottfries (2002). We see that there is a strong correlation between competitiveness and the relative price of exports for

[1] For a comprehensive survey of the evolution of the research on ERPT, see e.g. Goldberg and Knetter (1997) and the references therein. Further, for recent empirical evidence on ERPT, see for instance Campa and Goldberg (2002), Campa and Goldberg (2005) and Gottfries (2002) study of the ERPT in Swedish export markets.

[2] For instance, see Deveraux and Engel (2002) and Corsetti and Pesenti (2005) who analyze how optimal monetary policy depends on the extent of ERPT.

the sector producing transport equipment. The relative price is defined as $pr = p - s - p^*$, where $p$ is the Swedish export price index, $s$ is a trade-weighted nominal exchange rate, defined as the number of units of the Swedish krona for each unit of the trade-weighted foreign currency and $p^*$ is the trade-weighted foreign price. Competitiveness is measured by wages relative to foreign prices, i.e. $wr = w - s - p^*$, where $w$ is hourly wages. Both $pr$ and $wr$ are in Swedish currency. From Figure 1, it is apparent that relative prices depend on costs relative to foreign prices. However, the variation in relative prices is smaller than the variations in costs relative to foreign prices. A possible explanation for this is that cost increases are only partly passed through into export prices. Thus, PTM behavior by the exporting firms could explain the smaller variation in relative prices as compared to the variation in costs relative to foreign prices.[3]

In this paper, I investigate how export prices in Sweden are affected by shocks to the exchange rate, to the exporting firms' marginal costs, and to foreign prices. Further, I combine the above mentioned static and dynamic aspects of ERPT. Thus, I want to combine LCP and PCP with different degrees of PTM to analyze the dynamic effects of changes in the exchange rate on prices. More specifically, I study theoretically how export prices evolve after an unexpected and long-lasting change in the exchange rate under the assumption of LCP and PTM and PCP and PTM. I also look at the special case where we have no PTM but a 'Constant Desired Markup' (henceforth CDM). The case where the desired markup is constant is the standard case in macroeconomic models where firms set prices with a fixed markup over expected marginal costs. After that, I take a look at data to see which theory predicts actual outcome the best. The analysis is made within a VAR framework. Thus, the analysis is multivariate, in contrast to the partial equilibrium approach which is the most common empirical approach in the literature. Using VARs allows me to identify specific orthogonal shocks which affect the system of variables with a minimum of identifying assumptions and to analyze the size and the speed of effects of different shocks.

Overall, the results indicate that the responses of export prices (in SEK) to exchange rates are in line with PCP+PTM for a majority of the included sectors. Foreign prices affect export prices in SEK. For many of the included sectors the responses are in line with PTM. Finally, the effects of shocks in wages are weak and insignificant.

In Section 2 there is a brief review of the literature and empirical results in earlier studies of PTM. In Section 3, the theory underlying the empirical part will be presented. More specifically, I analyze the dynamic response of prices (in SEK) to unexpected and long-lasting changes in exchange rates, wages, and foreign prices. In Section 4, the data are described; these data are chosen to provide as good as a link as possible between theory and empirics. Section 5 and Section 6, contain the empirical specification, results, some variance decomposition, and a robustness check. In Section 7, I conclude the paper.

[3]For a detailed description of the events behind the developments in relative prices and competitiveness, I refer to Gottfries (2002).

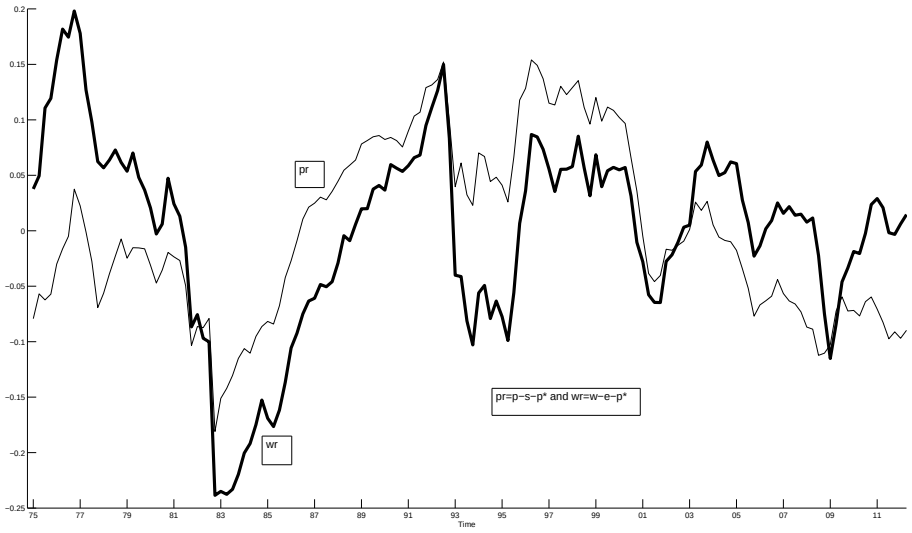


Figure 1: Swedish Export Price ($p$), Wages ($w$) Relative to Foreign Prices ($p^*$) for the Sector Producing Fabricated Metal Products, Machinery, and Equipment

## 2 A Brief Review of the Literature

The literature concerning incomplete ERPT is substantial. For example, Dornbusch (1987), Krugman et al. (1987), Giovannini (1988), and Feenstra (1989) found that U.S. import prices did not fall as much as the dollar value of the foreign currencies during the period when the dollar appreciated, i.e $1975 - 1985$. A more recent study by Vigfusson et al. (2007) also concludes that ERPT to U.S. import prices is relatively low.

The theory behind PTM and its empirical grounds is developed by Gagnon and Knetter (1995), and more formally by Knetter (1995). The theory in Knetter (1995) implies that there are adjustments of the markup following changes in the exporters' marginal costs and/ or changes in destination-specific exchange rates. These adjustments of markups imply that when the currency of the exporting firm appreciates against the currency of an importing country, the exporting firm absorbs part of this appreciation by reducing the export price denominated in its own currency. Thus, the import price denominated in the importing country's currency increases by a magnitude less than the appreciation of the exporting firm's currency.

Most empirical studies of price setting behavior and PTM have been made for large countries such as the United States, Japan, and Germany.[4]. The empirical evidence for small-open countries

[4]For instance, see Knetter 1989.

is limited. However, for Sweden, two studies of PTM are especially worth mentioning. Both these studies concern the export side. Alexius and Vredin (1999) investigate whether relative export prices are in line with the theory of PTM. They show that for most cases, there are deviations from no PTM and that relative export prices fluctuate with changes in aggregate demand, such as unemployment, and real and/ or nominal exchange rates in the destination countries. Using a vector error correction model, Adolfson (2001), investigates the export price response to three different exchange rate movements. Using data on Swedish exports of automobiles and kraft paper to Germany, France, and the United Kingdom, she finds results that are consistent with PTM. Clearly, exporters pay attention to foreign conditions and ERPT is incomplete.

The early empirical papers investigating PTM, such as Gagnon and Knetter (1995) and Knetter (1995), are micro oriented and they pay less attention to dynamics. On the macro side, the standard approach in the new Keynesian literature has been to assume staggered price setting with constant desired markups, see e.g. Galí et al. (2001). Constant-elastic demand implies that exporters do not vary their desired markups in response to exchange rate changes, i.e. there is no PTM. In this paper, I go a step further in that I consider a theoretical model with staggering pricing combined with PTM. Thus, I combine the macro and micro approaches that have been used to examine these issues.

# 3 Theoretical Framework

In this section, I describe a partial equilibrium model to derive some empirical predictions. I plot the impulse response functions for shocks to the exchange rate, wages, and foreign prices under LCP and PCP in combination with PTM or CDM. These will then be compared to the impulse response functions that are estimated from actual data. According to earlier work, see for instance Knetter (1995), PTM means that changes in conditions in the destination market lead exporters to adjust their markups.

Following the macro literature, I assume a staggered price setting in line with Calvo (1983).[5] At each point in time, the firm faces a constant probability that it will be able to change its price. This probability is equal to $1-\theta$. I assume that the desired price for the exporting firm is

$$p_t^d = \lambda \left(p_t^* + s_t\right) + (1-\lambda)\, w_t. \tag{1}$$

where $p_t^d$ is the desired export price in the exporter's currency, $p_t^*$ is the price that foreign competitors charge in foreign currency, $s_t$ is the exchange rate defined as the number of units of the

[5] A time-dependent pricing rule à la Calvo is in line with empirical observations on pricing behavior of firms operating in the manufacturing sector, see for instance Apel et al. (2005). The included sectors in this paper all operate in the manufacturing industry. Thus, it seems realistic to assume a time-dependent pricing rule for these firms.

exporting country's currency for each unit of the importing country's currency, and $w_t$ is the wage in the exporter's currency, which serves as a proxy for marginal costs. Lower-case letters are logs. Foreign prices ($p^*$), the exchange rate ($s$), and the wage ($w$) are all modeled as exogenous autoregressive processes. The parameter $\lambda$ measures the extent to which firms price to the market. If $\lambda = 0$, we have a constant desired markup and firms try to price with a constant markup over wages. The closer $\lambda$ is to 0, the more firms pass-through changes in exchange rates to export prices in foreign currency so there is less of PTM. Traditionally, in macroeconomic models, the most common approach is to assume that demand is constant-elastic, i.e. $\lambda = 0$. However, studies on firms' pricing behavior suggest that it is more reasonable to assume that price elasticity is increasing (in absolute value) in the relative price. Thus, the pass-through is less than complete and we have PTM; see for instance Gottfries (2002) and Forslund et al. (2008).

The optimal price for a firm that gets to reset its price in period $t$ given that it faces a probability of $(1-\theta)$ of resetting its price in each period is

$$p_t^r = \sum_{j=0}^{\infty} \beta^j \theta^j E_t p_{t+j}^d. \tag{2}$$

where $p_t^r$ is the reset price and $\beta$ is the discount factor. Thus, the average export price under PCP can be written as

$$p_t^{PCP} = \theta p_{t-1}^{PCP} + (1-\theta)\, p_t^r. \tag{3}$$

Similarly, the aggregate price in the exporter's currency under LCP is

$$p_t^{LCP} = \theta \left( p_{t-1}^{LCP} + \Delta s_t \right) + (1-\theta)\, p_t^r. \tag{4}$$

In the special case of CDM ($\lambda = 0$) and PCP, there is no direct effect of the exchange rate on prices. Assuming LCP+CDM, there is a full but temporary effect of the exchange rate on prices. The prices (in home currency) of firms that do not reset their prices will change mechanically one-to-one with the exchange rate. This implies an overshooting of the export price measured in the exporter's currency.

The parameter values for the simulation exercise are depicted in Table 1.

| Parameter | Value |
|---|---|
| Discount Rate ($\beta$) | 0.99 |
| Probability of Changing Prices ($1-\theta$) | 1/3 |
| PTM Coefficient ($\lambda$) | 0 (CDM) or 0.5 (PTM) |
| $\rho$ in the AR Processes | 0.95 |

Table 1: Parameter Values (Period Is One Quarter)

## 3.1 Effects of Changes in Exchange Rates

### 3.1.1 Constant Desired Markup

First, we have the standard case where the desired markup is constant (CDM). This case is illustrated in Figure 2. With LCP and CDM, we see an immediate increase in export prices in response to a depreciation, but then there is a fast downward adjustment. This is because the desired markup is constant, so the price increase (in domestic currency) was undesired. If we instead assume PCP and CDM, the response of export prices to a depreciation is zero. This is because exporting firms set prices with a constant markup over wages independent of competitors' prices. Thus, the price in the importing country fluctuates fully with the exchange rate.

### 3.1.2 Pricing to Market

Second, we look at the case of PTM (i.e. $\lambda = 0.5$). From Figure 3, we see that LCP implies an immediate increase in the exporter's price when the exchange rate depreciates**.** Export prices are then adjusted downward. The initial increase in the markup is too large. Firms want to increase their prices but not as much as the currency depreciated. Looking at the results for PCP, we see that exporters gradually raise their prices after a depreciation. This is because under PTM, prices are rigid in the currency of the exporting firm. A depreciation implies that there is an increase in the prices of the competitors, measured in the exporting firm's currency and firms increase their markups in response to this price increase, but less than the depreciation and with a lag. Thus, there is a slow and incomplete pass-through to import prices.

Finally, since the wage is modeled as an exogenous process, the response of wages to changes in the exchange rates is zero. The response would certainly be different if wages were to respond to the exchange rate shock. This partial equilibrium model has wages that are exogenous and constant. The validity of this assumption is further investigated in the empirical part, where wages are endogenous in the VAR system.

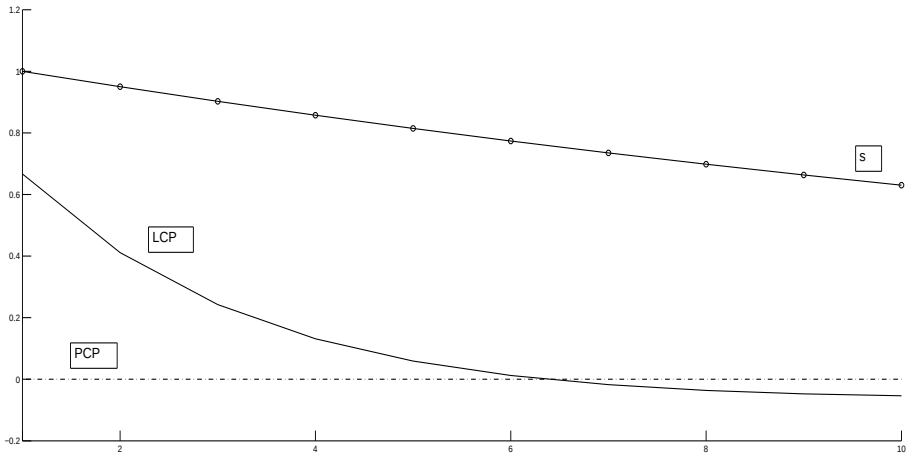


Figure 2: The Response of Export Prices to a Depreciation under Constant Desired Markup ($\lambda = 0$)

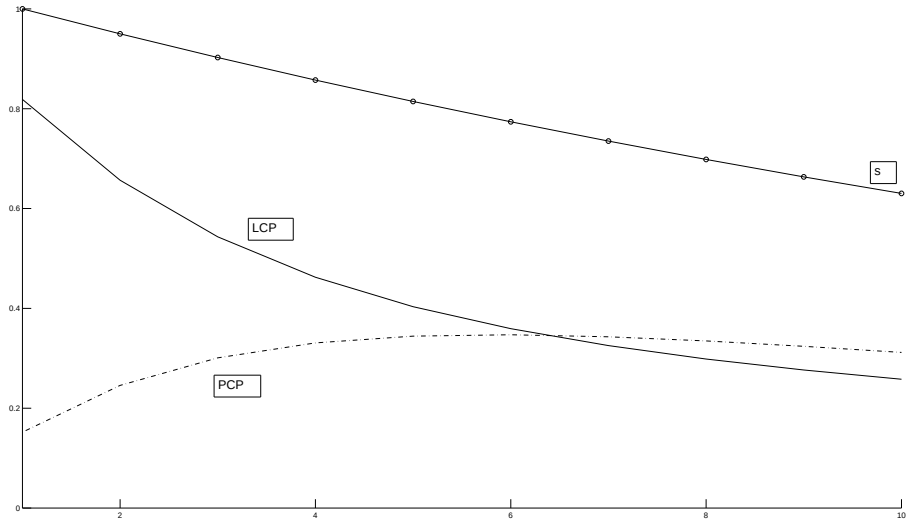


Figure 3: The Response of Export Prices to a Depreciation under PTM ($\lambda = 0.5$)

## 3.2 Effects of Changes in Foreign Prices

An increase in foreign prices implies the same response under LCP and PCP. With PTM (regardless of which currency prices are set), there is a gradual increase in export prices and the maximum effect is reached after approximately four periods, as can be seen from Figure 4. With CDM, the response of prices to a shock in foreign prices is zero. When the markups are constant, firms only react to costs and foreign prices are of no importance for the firm's pricing decision.

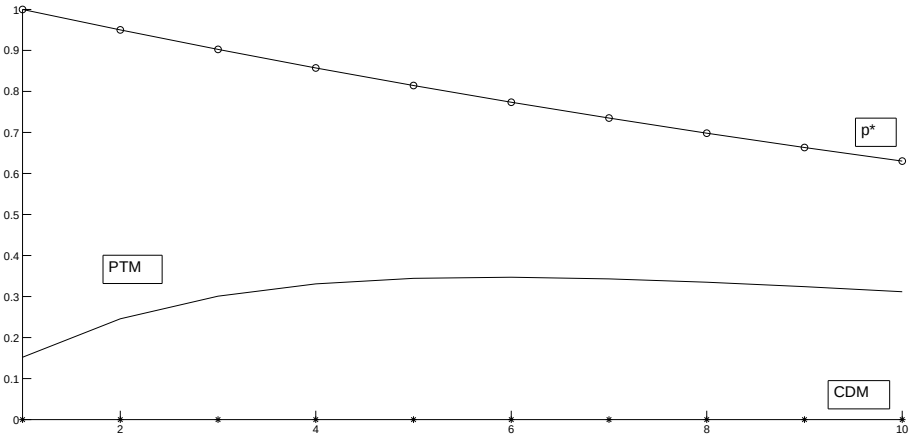


Figure 4: The Response of Export Prices to an Increase in Foreign Prices

## 3.3 Effects of Changes in Wages

An increase in wages implies identical responses, regardless of which currency prices are set. The implications of a variable markup are illustrated in Figure 5. There is an increase in export prices since there is an increase in costs but the response is gradual. The response is larger in the case with CDM than in the case with PTM. When firms price to the market, they do not increase the prices to the same extent as those firms which have constant markups because they want to remain competitive.

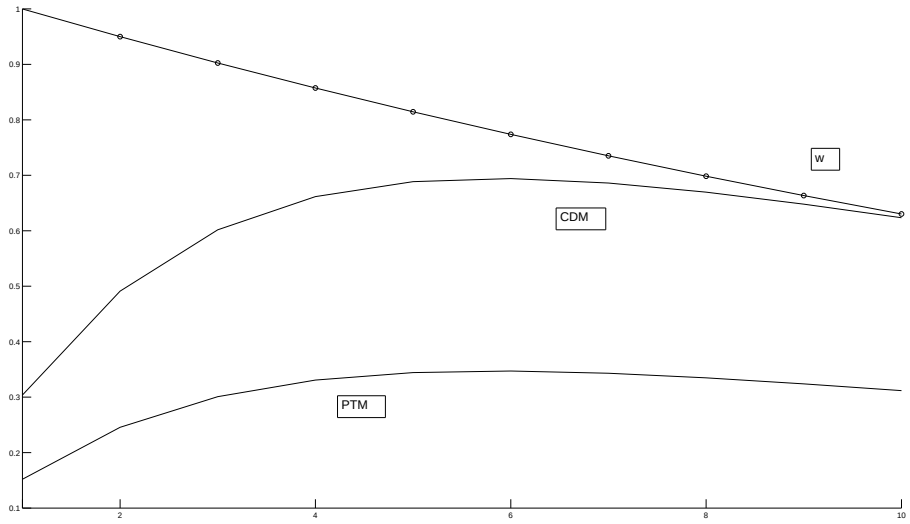


Figure 5: The Response of Export Prices to a Positive Shock in Wages

# 4 Data

This analysis uses quarterly data on export price index ($p$), exchange rates ($s$), wages ($w$), and a proxy for competitors' prices ($p^*$). The data set comprises quarterly observations from 1975 to today.[6] Plots of the variables are shown in Figures A3.1-A3.7 in Subsection (A3.1) in the appendix. I estimate VAR models and plot the impulse response functions to various shocks. I divide the data set into two subperiods. The first period is 1975Q1-1994Q4. The second period begins in 1995Q1 and ends either in 2009Q4 or 2012Q2, depending on data availability. The reason for dividing the data set into these two periods is that they are very different when it comes to exchange rate regimes and monetary policy. During the period 1975-1992, the Swedish Krona was fixed or pegged to a currency basket and this ended with a big depreciation in November 1992. In 1993, the Swedish central bank switched to an inflation targeting regime with a floating currency. I start the second period in 1995 by assuming that the inflation targeting regime had been well established at that point. We could expect that the effects of an exchange rate shock should differ between these two periods. In the first period, the major exchange rate movements were associated with devaluations of the Swedish Krona, so agents would not expect the nominal exchange rate to revert to its

[6]For some sectors, data on export prices are only available to 2009Q4. These sectors are sector 21+22 (Pulp, Paper, Paper Products, Printed Matter and Recorded Media) and sector 34+35 (Transport Equipment Except Ships and Boats).

previous level after a depreciation. This implies that exporting firms want to adjust their prices permanently, resulting in an increasing willingness to adjust prices today (under the assumption of Calvo pricing). In the second period, we had a floating exchange rate and exchange rate shock may be more temporary. Consequently, exporting firms would not adjust their prices to the same extent as in the first period. Thus, exporting firms may take into account that the exchange rate may be more mean-reverting in the second period as compared to the first period.

Data on export prices have been obtained from Statistics Sweden.[7] The export price indices are on the two-digit level and include products which constitute a large part of Swedish exports, for instance mineral products, machinery, transport equipment and paper products. Previous research has shown that the choice of currency when setting prices is different for different sectors. For instance, using data on currency and prices for US imports, Gopinath et al. (2010) show that the currency choice differs between sectors. Sectors producing more homogenous products, like mineral products often have their prices set in dollars, while sectors producing more differentiated goods, for instance machinery, are more likely to set prices in non-dollar currencies. Thus, according to this line of reasoning, one would expect a higher share of LCP firms in more homogenous goods sectors and a higher share of PCP firms in sectors producing more differentiated goods. Moreover, ex ante one would expect that the included sectors differ when it comes to the PTM behavior. Sectors producing more differentiated goods, such as automobiles and trucks, should have larger possibilities to price discriminate between different markets as compared to more homogenous sectors such as basic metals and pulp, paper, and paper products. Further, the market for sectors producing differentiated goods such as automobiles is rather segmented while sectors producing basic metals and pulp, paper, and paper products would be expected to sell their products in a more integrated world market.[8]

Moreover, I use data on nominal exchange rates which are obtained from Sveriges Riksbank, which constructs long time series data on exchange rates. As a proxy for the competitors' price, I use Producer Price Indices (PPI) for the manufacturing industry for 13 countries which are Sweden's most important trade partners.[9] PPI is then multiplied by sector-specific trade weights in order to obtain a trade-weighted measure of the competitors' price. The sector-specific trade weights are constructed by dividing the total value of exports (in SEK) to country $j$ in sector $i$ by total Swedish exports in sector $i$ in the year of 1990, approximately in the middle of the included sample. The exchange rates series is also sector-specific and is constructed by multiplying a country's export trade weight in a sector by the nominal exchange rate and then taking the sum

[7] For a more detailed description of the data, see Subsection A3.2 in the appendix.

[8] According to Goldberg and Knetter (1997), automobiles is classified as a segmented market due to for instance additional taxes at the boarder, safety and environmental regulations, and warranties and services that are destination-specific.

[9] For some countries, PPI for the manufacturing industry is not available for the whole estimation period. For those years, PPI for all goods is used as a proxy. For France, PPI (either for manufacturing or total) is missing for the period $1975 - 1994$. As a proxy for PPI for the missing years, I use the GDP deflator.

across all countries. [10] The countries included in the construction of the exchange rates series and the competitors' price series are countries which constitute a significant part of the exports and imports of Sweden. More specifically, these countries are the Nordic countries (i.e. Norway, Finland, and Denmark), Western European countries (Germany, France, Italy, Belgium, the Netherlands, the United Kingdom, Switzerland, and Austria) and North American countries (i.e. the United States and Canada). Wages (i.e. hourly earnings), which serve as a proxy for marginal costs, are for the manufacturing industry and are obtained from the OECD. Moreover, all variables are in logs and are denoted by small letters, i.e. $\ln(P) = p$.

An appropriate VAR in levels is used.[11] This despite the fact that exchange rates $(s)$, export prices $(p)$, and wages $(w)$ are non-stationary.[12] The null hypothesis of a unit root can be rejected at a 10 percent level only for producer prices of foreign firms $(p^*)$. However, theoretically one would expect that this variable should be $I(1)$. Therefore, I conclude that this variable is non-stationary.[13] The alternative of differencing the data when they are not stationary is not employed here. Overdifferencing would imply a loss of information. Further, according to Sims, et al. (1990), the estimator in levels is consistent when estimating VARs in levels. However, according to Stock and Watson (2001), standard errors for impulse responses might imply results that are misleading. Bootstrapping methods can improve some of these standard methods and, therefore, I choose to estimate the VAR in levels and bootstrap the confidence intervals.

The appropriate lag length has to be chosen in order to specify the VAR. Lag lengths are chosen based on BIC, the results of which are complemented by tests for serial correlation in the residuals.[14] The results of appropriate lag length for all sectors and for both periods are listed in Table 2.

[10] More specifically, the export weighted exchange rate is calculated according to $s_{it} = \sum_{j=1}^{13} w_{ij} s_{jt}$, where $s_{it}$ is the nominal exchange rate in sector $i$ in period $t$, $w_{ij}$ is the export trade weight in sector $i$ for country $j$ and $s_{jt}$ is the nominal exchange rate in period $t$. On average, the sector-specific export trade weights cover 80 % of the total value of exports. The weights are then adjusted so that they sum to 100. Similarly, competitors' price is calculated according to $p^*_{it} = \sum_{j=1}^{13} v_{ij} p^*_{jt}$ where $v_{ij}$ is the export trade weight in sector $i$ for country $j$ and $p^*_{jt}$ is foreign prices in country $j$ in period $t$. Also, the weights are adjusted so that they sum to 100.

[11] See Hamilton (1994) and Lütkepohl (2006) for a detailed description of the VAR methodology.

[12] The results of the Augmented Dickey Fuller (ADF) test are presented in Subsection A3.2 in the appendix.

[13] The ADF test for producer prices dividing the sample into the two periods (i.e. 1975-1994 and 1995 and forward) indicated that the PPI- series included in the empirical specification are non-stationary, even at the 10% level. The reason for reporting the ADF-test for the whole sample is that the probability of not rejecting the null hypothesis of a unit root is larger in small samples than in larger samples, thus the probability of a type II error increases in small samples.

[14] More specifically, the Lagrange multiplier (LM) test at lag-length 1, $LM(1)$ and lag length 4, $LM(4)$. If the BIC and LM test indicate different results, the lags suggested by the LM test will be chosen. This is because the fact of severely biased estimates when serial correlation remain.

| Sector | Period 1 (1975Q1-1994Q4) | Period 2 (1995Q1∼) |
|---|---|---|
| Food Products, Beverages, and Tobacco Goods | 3 | 3 |
| Textiles | 3 | 4 |
| Chemicals and Chemical Products etc. | 3 | 3 |
| Mineral Products | 3 | 4 |
| Basic Metals | 3 | 3 |
| Pulp, Paper, Paper Products, Printed Matter etc. | 5 | 3 |
| Fabricated Metal Products, Machinery and Equipment | 3 | 2 |
| Transport Equipment Except Ships and Boats | 3 | 3 |

Table 2: Chosen Lag Lengths

# 5 Empirical Specification

The reduced-form VAR in its compact form looks as follows[15]

$$A(L) Z_t = e_t \tag{5}$$

where $A(L) = I_K - A_1 L - ... - A_p L^p$ , $L$ is the lag operator (i.e. $LZ_t = Z_{t-1}$), $Z_t$ is a vector of endogenous variables, and $e_t$ is a vector of the reduced-form residuals.[16] More specifically, in this analysis, $Z_t = (p_t^*,\ w_t,\ s_t,\ p_t)'$ and $e_t = \left(e_t^{p*},\ e^{w_t},\ e^{s_t},\ e^{p_t}\ \right)'$. The ordering of the above variables is motivated by theory according to the following reasoning: 1) Foreign prices assuming a small-open economy so that shocks to foreign prices are exogenous, 2) wages since they are predetermined in one-, two- or three-year wage contracts and set before prices, 3) the exchange rate and 4) the export price of Swedish firms which is assumed to respond to exchange rates, costs, and competitors' prices. However, in the robustness check, I test for the robustness of alternative specifications.

In line with Sims (1980), I use a Cholesky decomposition in order to identify shocks that are orthogonal. The Cholesky decomposition implies a decomposition of the variance-covariance matrix of the reduced-form residuals in a lower triangular matrix $S$ and an upper triangular matrix $S'$. There are $n(n-1)/2$ economic restrictions that are necessary to identify the structural model. These restrictions are imposed as zero restrictions on the matrix $S$. The matrix $S$ is the link between the reduced form and the orthogonal residuals. Economically, these restrictions imply that there is no contemporaneous impact of some of the shocks on some of the variables in the system. More specifically, current values of the variables only depend on current values of the shocks that

[15] The estimated VAR(q) models are stationary for all sectors for both periods except for textiles period 2. However, for textiles the VAR model is stationary for the whole sample. The result is based on the inverse roots of the characteristic polynomial. The estimated VARs are stable, i.e. stationary, since all roots have modulus less than one and lie inside the unit circle.

[16] For simplicity, the deterministic terms are neglected in the specification. However, the VARs are specified with a constant and seasonal dummies. However, a standard 0-1 seasonal dummy is not included in the VARs since this affects both the mean and the trend of the level series $y_t$. To circumvent this problem, I proceed using centered seasonal dummies, a standard way removing seasonality in VAR-models. These centered seasonal dummies can shift the mean without contributing to the trend.

are above that variable in the system of equations. For this paper, ordering foreign prices first implies that shocks to foreign prices, $\epsilon_t^{P^*}$, may have a contemporaneous effect on the reduced form residuals of all equations and hence all variables in the system. On the other hand, the reduced form residuals of foreign prices, $e_t^{P^*}$, are not affected contemporaneously by any other shocks in the system (see Equation(6)).

Using the ordering of the variables as in $Z_t$, the relationship between the reduced form residuals, $e_t$, and the orthogonal shocks, $\epsilon_t$, of the model can be written according to

$$\begin{bmatrix} e_t^{P^*} \\ e_t^w \\ e_t^s \\ e_t^P \end{bmatrix} = \begin{bmatrix} S_{11} & 0 & 0 & 0 \\ S_{21} & S_{22} & 0 & 0 \\ S_{31} & S_{32} & S_{33} & 0 \\ S_{41} & S_{42} & S_{43} & S_{44} \end{bmatrix} \begin{bmatrix} \epsilon_t^{P^*} \\ \epsilon_t^w \\ \epsilon_t^s \\ \epsilon_t^P \end{bmatrix}. \tag{6}$$

# 6 Empirical Results

In this section, I present the impulse responses with respect to shocks to the Swedish exchange rates, wages, and foreign prices. The first period begins in 1975. This was a period with a fixed exchange rate (to a basket) but frequent exchange rate adjustments occurred. The second period begins in 1995 and is a period with an established inflation targeting regime and a floating exchange rate. For comparative reasons, the results for the first and second period are shown in the same figure.

Further, some variance decomposition showing the relative importance of exchange rate shocks, shocks to wages, and shocks to foreign prices for fluctuations in the export prices will be presented. Finally, some robustness test is performed in order to test the validity of the results to alternative identification schemes.

## 6.1 Effects of an Exchange Rate Shock

In Figures 6-9, I plot the responses of export prices to a shock equal to a one standard deviation in the exchange rate, i.e. a depreciation. The results for periods 1 and 2 for all sectors are shown. I choose to include a horizon corresponding to approximately four years. The reason for including a rather long horizon is to see whether impulses "die out" at zero. This should be the case in a stationary VAR. The confidence intervals were computed by bootstrapping (2000 repetitions). In order to interpret Figures 6-9, we compare them to the impulse response functions derived in Section (3), i.e. Figures 2 and 3. From Figures 6-9 we see that, in line with theory, export prices (in the exporter's currency) increase in response to a depreciation. Moreover, by looking at Figures 6-9, we see that these increases are significant for a majority of the included sectors. This can be seen by comparing the impulse responses in Figures 6-9 with the theoretical counterparts, i.e. Figures 2-3,

which illustrate the responses of export prices to a depreciation under CDM and PTM for PCP and LCP. By looking at Figures 6-9, we see that the empirical dynamics is most consistent with PCP. Thus, a majority of the included sectors appear to price in the domestic currency. Moreover, there is evidence of PTM. This is most apparent for sectors producing metal products, machinery, and equipment and transport equipment. The early work of Krugman et al. (1987) also concluded that PTM is present for machinery and transport equipment. This should not be too surprising, though, since PTM should be more common in sectors where goods are more differentiated and where the exporting firm wants to stabilize prices in the importing country's currency. Further, relating the result to existing Swedish evidence, the results in this paper are in line with Gottfries (2002), who also concludes that many exporting firms appear to set their prices in kronor and in line with PTM. Moreover, the results are rather robust when comparing periods. The persistence of shocks to the exchange rate is similar in periods 1 and 2. It could have been expected that the switch to a flexible inflation targeting regime and a floating exchange rate regime would have implied exchange rate shocks of a more temporary character in period 2. However, this does not seem to be the case.

Finally, the results of the responses of wages to a depreciation are depicted in Figures A3.8-A3.11 in Subsection (A3.3) in the appendix. The confidence intervals are also plotted. We see that the responses of wages to a depreciation are insignificant for a majority of the cases. However, for some cases, the empirical responses of wages to a depreciation are significant. This is the case for Textiles period 1 (Figure A3.8), Chemicals and Chemical Products period 1 (Figure A3.9), Basic Metals period 1 (Figure A3.10), and Pulp, Paper, and Paper Products period 1 (Figure A3.10). A possible explanation for this could be the following: the exchange rate reverts to its level before the exchange rate shock after approximately 1.5-2 years. For Textiles period 1 (Figure A3.8), Chemicals and Chemical Products period 1 (Figure A3.9), Basic Metals period 1 (Figure A3.10), and Pulp, Paper, and Paper Products period 1 (Figure A3.10), we saw that wages increase in response to the depreciation. Theoretically, it could be expected that due to the wage increase, there is a persistent increase in prices. Looking at Figure (6) for Textiles Period 1, Figure (7) for Chemicals and Chemical Products period 1, Figure (8) Basic Metals period 1 and Pulp, Paper, and Paper Products period 1, we see that this is also the case. Prices increase persistently and one possible explanation for this could be the significant wage increase due to the depreciation.

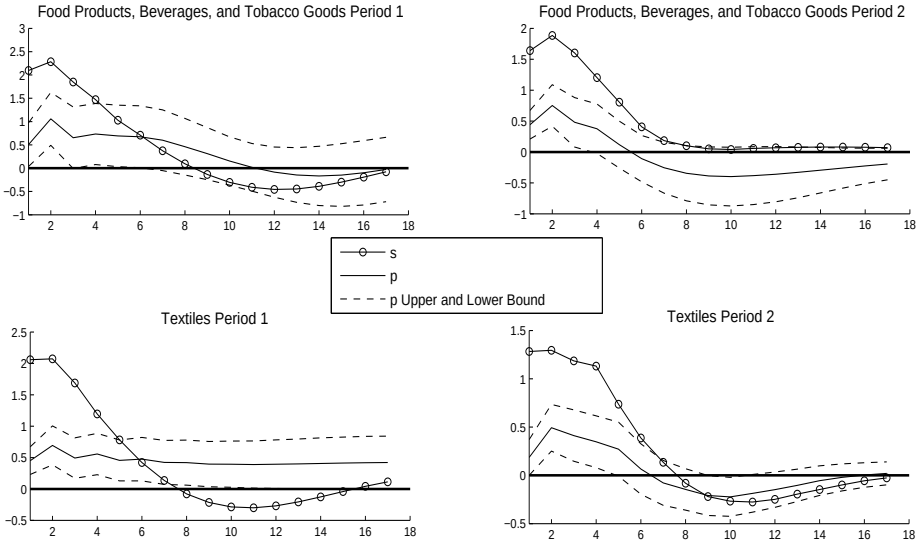


Figure 6: Impulse Responses to a Depreciation. Solid Lines Show the Responses of the Export Price and Dashed Lines Are 95 Percent Confidence Intervals. Solid Lines with Circles Are the Responses to the Exchange Rate.

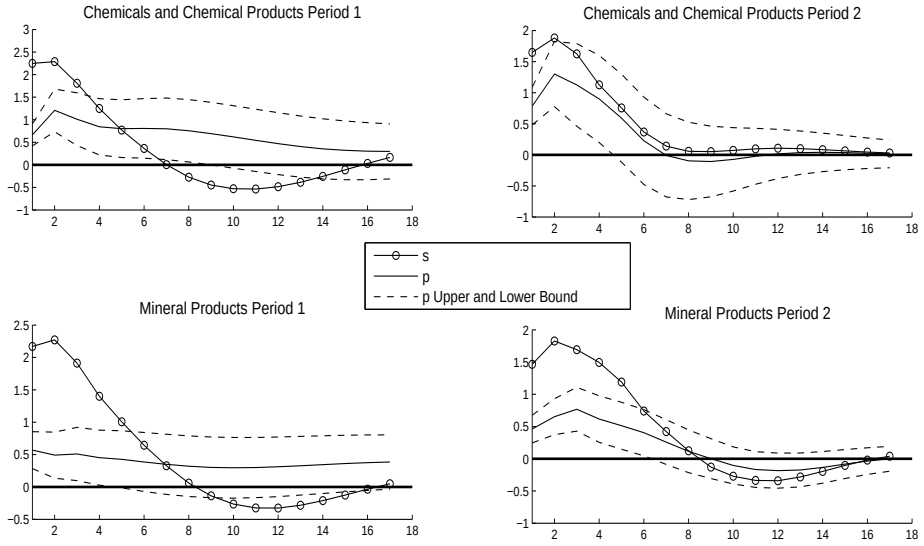


Figure 7: Impulse Responses to a Depreciation. Solid Lines Show the Responses of the Export Price and Dashed Lines Are 95 Percent Confidence Intervals. Solid Lines with Circles Are the Responses to the Exchange Rate.

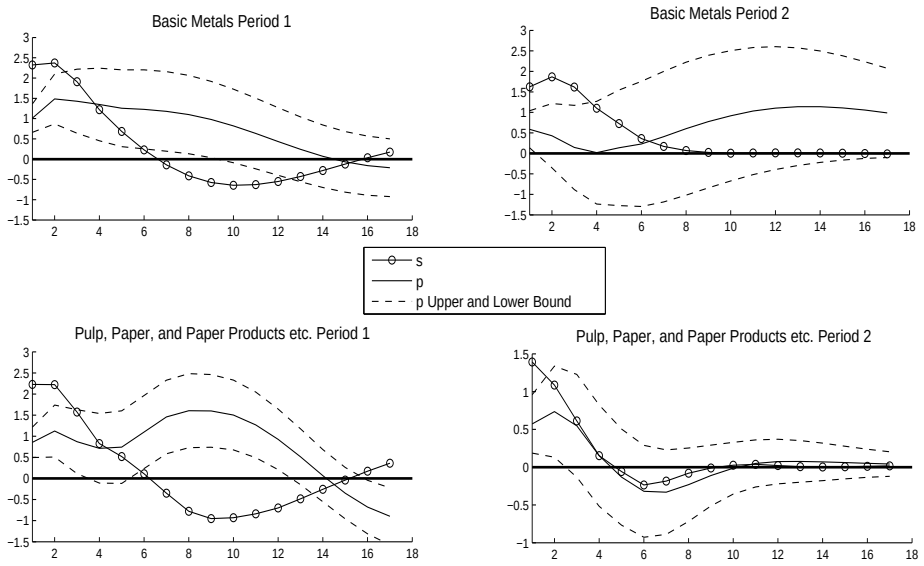


Figure 8: Impulse Responses to a Depreciation. Solid Lines Show the Responses of the Export Price and Dashed Lines Are 95 Percent Confidence Intervals. Solid Lines with Circles Are the Responses to the Exchange Rate.

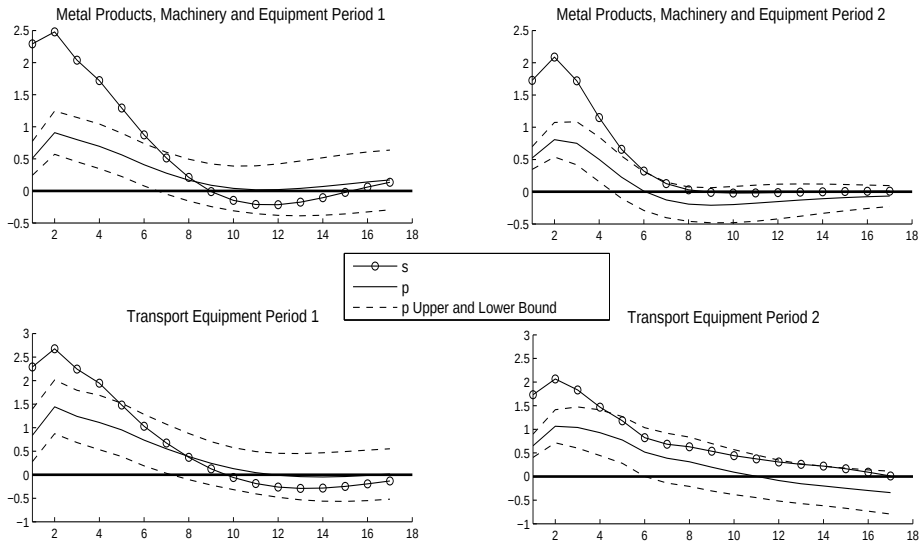


Figure 9: Impulse Responses to a Depreciation. Solid Lines Show the Responses of the Export Price and Dashed Lines Are 95 Percent Confidence Intervals. Solid Lines with Circles Are the Responses to the Exchange Rate.

## 6.2 Foreign Prices

Figures 10-13 illustrate the response of export prices to a one standard deviation shock in foreign prices. For half of the cases, there is an immediate and gradual increase in the responses of export prices (in SEK) to foreign prices. The gradual and hump-shaped increase in export prices is consistent with the theory of PTM (i.e. see Section 3, Figure 4), especially for sectors such as textiles (period 1), mineral products (period 1), metal products, machinery, and equipment (period 1), and transport equipment (period 1). Moreover, for these cases, the increase in export prices is statistically significant for all horizons (mineral products) or for later horizons (textiles, metal products, machinery, and equipment, and transport equipment). However, for period 2, and for a majority of the included sectors, there is an immediate decrease in export prices due to an increase in foreign prices. These results are not in line with theory. Finally, for some sectors, there is an overreaction of export prices to an increase in foreign prices. For instance, this is the case for chemicals and chemical products (period 1) and basic metals (periods 1 and 2). According to theory, this should not be the case. Thus, we conclude that foreign prices are important, but not as important as the exchange rate for exporting firms assuming PTM.

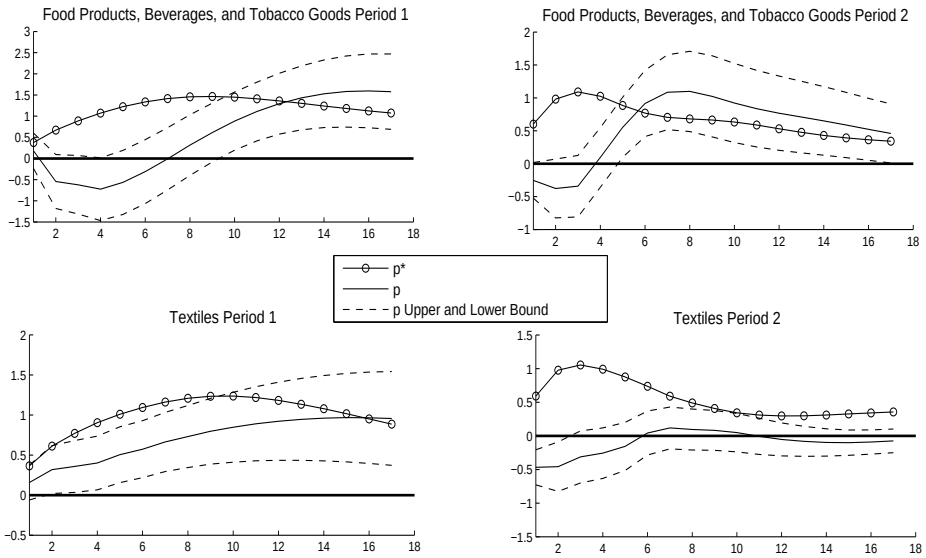


Figure 10: Impulse Responses to an Increase in Foreign Prices. Solid Lines Show the Responses of the Export Price and Dashed Lines Are 95 Percent Confidence Intervals. Solid Lines with Circles Are the Responses to Foreign Prices.

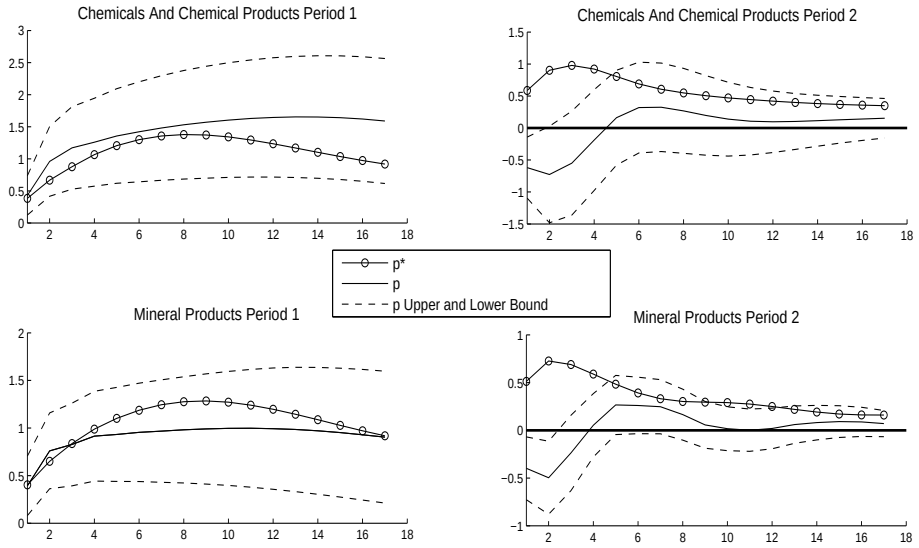


Figure 11: Impulse Responses to an Increase in Foreign Prices. Solid Lines Show the Responses of the Export Price and Dashed Lines Are 95 Percent Confidence Intervals. Solid Lines with Circles Are the Responses to Foreign Prices.

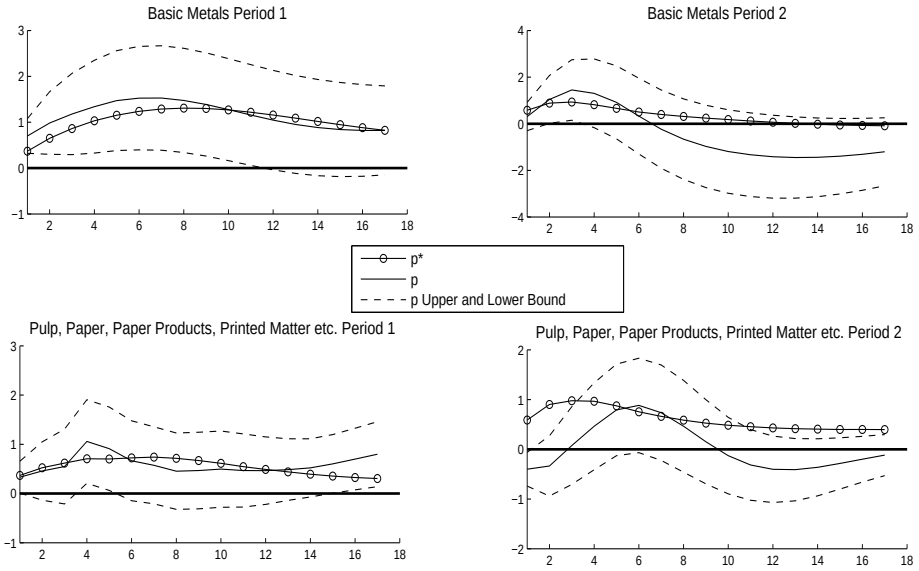


Figure 12: Impulse Responses to an Increase in Foreign Prices. Solid Lines Show the Responses of the Export Price and Dashed Lines Are 95 Percent Confidence Intervals. Solid Lines with Circles Are the Responses to Foreign Prices.

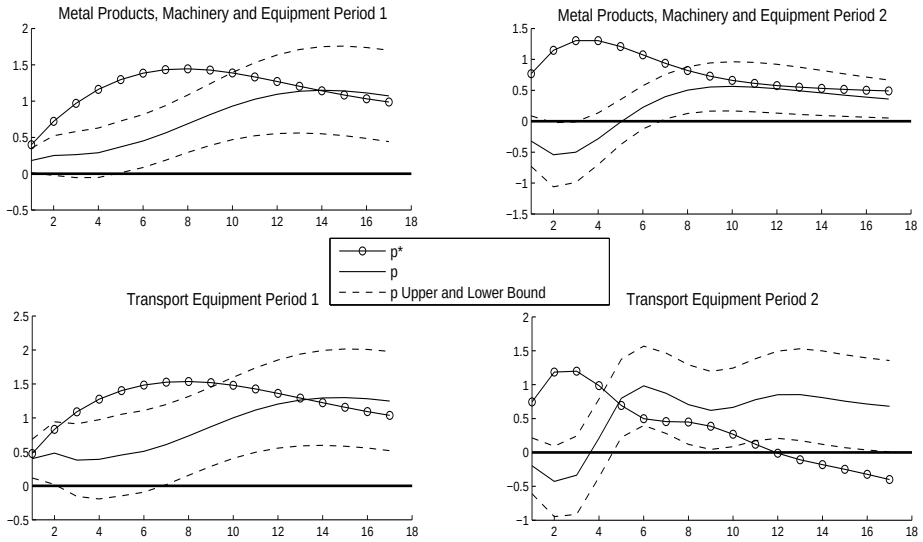


Figure 13: Impulse Responses to an Increase in Foreign Prices. Solid Lines Show the Responses of the Export Price and Dashed Lines Are 95 Percent Confidence Intervals. Solid Lines with Circles Are the Responses to Foreign Prices.

## 6.3 Effect of a Wage Shock

Figures 14-17 depict the responses to a one standard deviation shock in wages. We see that the response of prices to an increase in wages looks similar to the theoretical response in Figure 5 for sectors such as Textiles (period 1), Basic Metals (period 1), and Pulp, Paper, and Paper Products (period 1). The effect is insignificant in many cases. However, for some of these cases the effect of a wage shock is positive and occurs with a lag. This is the case for Textiles, Basic Metals (period 1), Metal Products, Machinery, and Equipment (period 1), and Transport Equipment (period 1). For period 2, for a majority of the included sectors, there is even a decrease in prices in response to an increase in wages, a result which is not in line with theory. This decrease in prices is even significant for approximately half of the included sectors. Thus, I conclude that a shock to wages seems to have an insignificant effect on export prices for many of the included sectors. For period 1, for those cases where the effect is significant, it is positive and occurs with a lag. For period 2, for those cases where the effect is significant it is immediate and negative, a result which is not in line with theory.

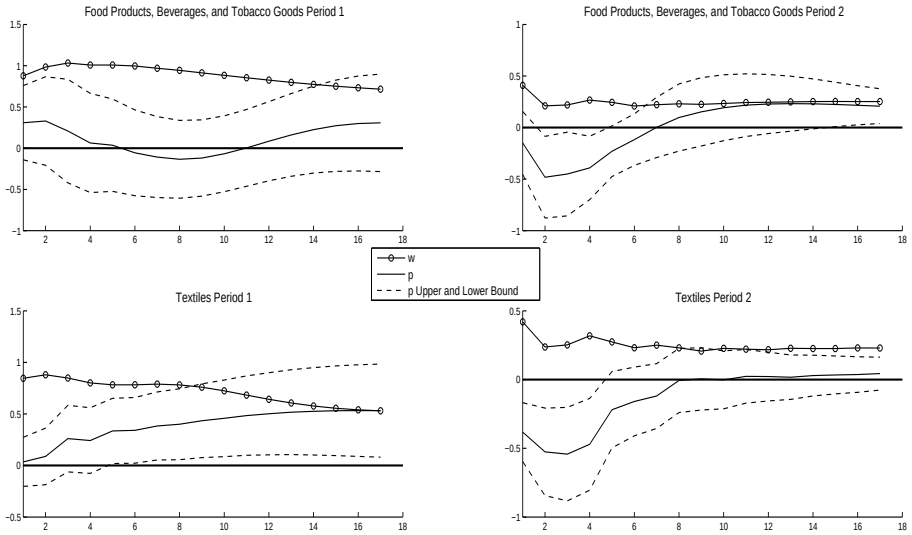


Figure 14: Impulse Responses to an Increase in Wages. Solid Lines Show the Responses of the Export Price and Dashed Lines Are 95 Percent Confidence Intervals. Solid Lines with Circles Are the Responses to the Wage.

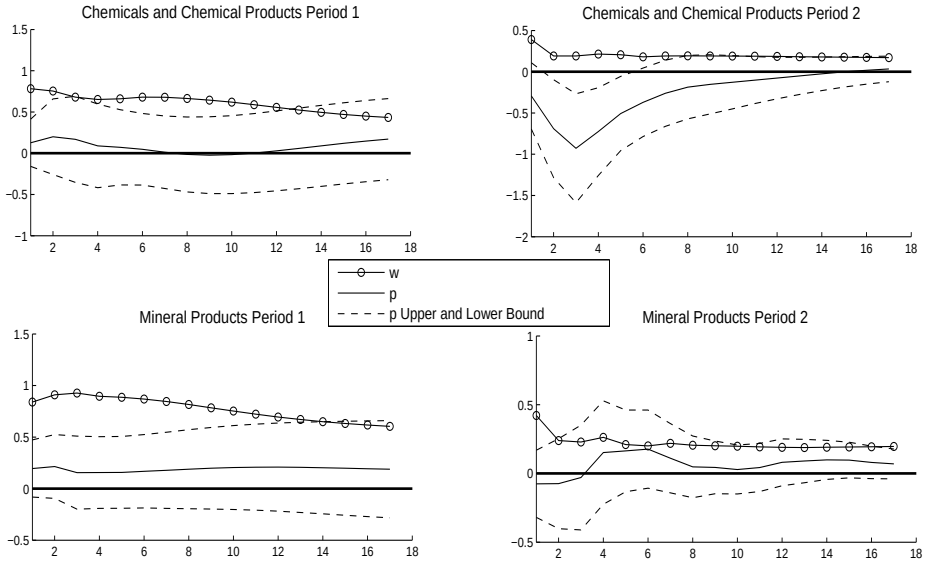


Figure 15: Impulse Responses to an Increase in Wages. Solid Lines Show the Responses of the Export Price and Dashed Lines Are 95 Percent Confidence Intervals. Solid Lines with Circles Are the Responses to the Wage.

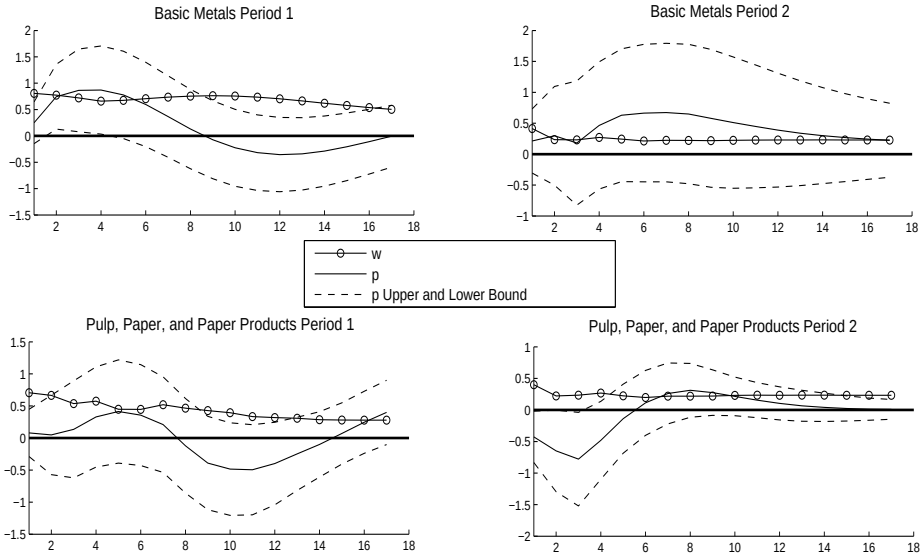


Figure 16: Impulse Responses to an Increase in Wages. Solid Lines Show the Responses of the Export Price and Dashed Lines Are 95 Percent Confidence Intervals. Solid Lines with Circles Are the Responses to the Wage.

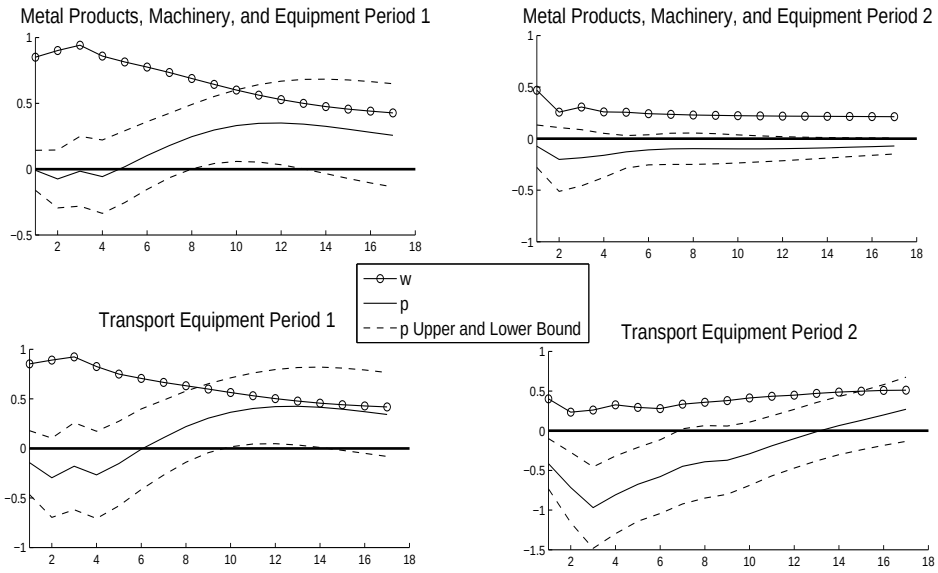


Figure 17: Impulse Responses to an Increase in Wages. Solid Lines Show the Responses of the Export Price and Dashed Lines Are 95 Percent Confidence Intervals. Solid Lines with Circles Are the Responses to the Wage.

| | Exchange Rate Shock ($e_s$) | | | | Wage Shock ($e_w$) | | | | Shock Foreign Price ($e_{p^*}$) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sector** | $p^*$ | $s$ | $w$ | $p$ | $p^*$ | $s$ | $w$ | $p$ | $p^*$ | $s$ | $w$ | $p$ |
| **Food Products, Beverages, and Tobacco Goods, Period 1** | 1.655 | 79.462 | 1.166 | 21.876 | 0.943 | 15.875 | 95.523 | 1.622 | 97.246 | 1.036 | 3.209 | 10.014 |
| **Food Products, Beverages, and Tobacco Goods, Period 2** | 10.164 | 61.030 | 2.996 | 14.615 | 3.940 | 10.079 | 44.252 | 7.480 | 85.222 | 28.306 | 50.321 | 41.988 |
| **Textiles, Period 1** | 1.262 | 69.916 | 3.594 | 27.824 | 13.592 | 17.268 | 84.649 | 9.233 | 84.0 | 0.901 | 7.194 | 27.149 |
| **Textiles, Period 2** | 7.515 | 51.872 | 0.820 | 19.849 | 4.974 | 6.410 | 55.629 | 30.295 | 86.933 | 22.491 | 40.917 | 18.932 |
| **Chemicals and Chemical Products etc. Period 1** | 1.303 | 81.782 | 12.190 | 24.007 | 2.450 | 5.453 | 80.315 | 0.392 | 94.925 | 1.226 | 3.163 | 48.681 |
| **Chemicals and Chemical Products etc. Period 2** | 11.627 | 65.506 | 1.373 | 24.606 | 0.542 | 3.760 | 32.832 | 12.599 69.839 | 29.820 | 63.549 | 7.992 | |
| **Other Non-Metallic Mineral Products etc. Period 1** | 1.147 | 81.147 | 2.061 | 13.946 | 0.140 | 5.922 | 80.456 | 2.224 | 86.492 | 1.024 | 1.547 | 52.243 |
| **Other Non-Metallic Mineral Products etc. Period 2** | 29.352 | 88.078 | 4.086 | 50.473 | 0.424 | 0.955 | 57.768 | 2.572 | 47.437 | 7.099 | 23.865 | 16.479 |
| **Basic Metals, Period 1** | 1.037 | 75.883 | 14.636 | 29.266 | 3.257 | 13.303 | 77.062 | 7.405 | 95.587 | 1.280 | 3.457 | 31.278 |
| **Basic Metals, Period 2** | 7.022 | 59.332 | 1.111 | 1.181 | 5.344 | 5.657 | 52.442 | 2.148 | 71.208 | 29.484 | 39.862 | 6.593 |
| **Pulp, Paper, Paper Products, Printed Matter etc., Period 1** | 1.379 | 85.129 | 11.870 | 27.052 | 14.081 | 7.736 | 75.542 | 1.370 | 73.267 | 2.331 | 1.665 | 9.855 |
| **Pulp, Paper, Paper Products, Printed Matter etc., Period 2** | 2.039 | 41.287 | 0.858 | 6.869 | 4.684 | 8.983 | 45.347 | 7.653 | 92.509 | 42.013 | 48.469 | 12.380 |
| **Fabricated Metal Products, Machinery** | 0.734 | 87.204 | 2.063 | 54.359 | 0.750 | 6.518 | 91.535 | 2.206 | 97.967 | 0.882 | 1.471 | 26.775 |

*Continued on next page*

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **and Equipment, Period 1** | | | | | | | | | | | | |
| **Fabricated Metal Products, Machinery** | 0.734 | 87.204 | 2.063 | 54.359 | 0.750 | 6.518 | 91.535 | 2.206 | 97.967 | 0.882 | 1.471 | 26.775 |
| **and Equipment, Period 2** | | | | | | | | | | | | |
| **Transport Equipment Except Ships** | 1.889 | 81.111 | 1.803 | 63.014 | 0.702 | 8.739 | 87.514 | 2.499 | 97.224 | 1.178 | 2.383 | 17.428 |
| **and Boats, Period 1** | | | | | | | | | | | | |
| **Transport Equipment Except Ships** | 12.082 | 59.830 | 3.177 | 35.198 | 17.272 | 17.273 | 60.309 | 26.124 | 67.506 | 17.038 | 31.106 | 24.748 |
| **and Boats, Period 2** | | | | | | | | | | | | |

Table 3: Forecast Error Variance Decomposition of $p^*$, $s$, $w$, and $p$ Due to Exchange Rate Shocks ($e_s$) , Wage Shocks ($e_w$), and a Shock in Foreign Prices ($e_{p^*}$), Horizon 8 Quarters.

## 6.4 Variance Decomposition

In Table 3, the forecast error variance decomposition for an eight quarter horizon is shown for the four endogenous variables. The results from this exercise indicate that shocks to the exchange rate account for a larger fraction of the variance in export prices ($p$) than do shocks to wages ($w$) and foreign prices ($p^*$). Thus, exchange rate shocks are an important determinant of prices. Especially, this is the case for period 1. Comparing period 1 with 2, we see that for period 1, the exchange rate accounts for a larger fraction of the variance of export prices compared to period 2. For instance, for period 1 for the sector producing transport equipment, it accounts for approximately 63 percent of the variance of the export prices two years after the shock. The corresponding number for period 2 is approximately 35 percent. Moreover, shocks to foreign prices are important when accounting for the variance of export prices. Here, for period 1 for the sector producing mineral products, the fraction of the variance of export prices which is accounted for by shocks to foreign prices is as high as approximately 52 percent. On the other hand, shocks to wages do not seem to explain much of the variance of export prices, with the exception of textiles (period 2), and transport equipment (period 2) for where it accounts for approximately 30 and 26 percent, respectively. Thus, of the three shocks, shocks to exchange rates and foreign prices seem to explain more of the forecast error variance of export prices than do shocks to wages. Thus, the results obtained by the decomposition of the forecast error variance decomposition further strengthen the conclusion that the exchange rate is important for explaining the variance in export prices, followed by shocks to foreign prices.

## 6.5 Robustness Check

The impulse response functions derived in Section 6 might be sensitive to how the model is identified. Economic theory, especially in the ERPT literature, provided a guideline for how to order the variables. However, the chosen ordering in Section 5 is one among several plausible orderings of the variables. Thus, a robustness check to test whether the results are sensitive to alternative identification schemes should be performed. The robustness of the results is tested by varying the ordering of the variables in the Choleski decomposition. In the baseline model, foreign prices were ordered first, followed by wages, exchange rates, and export prices. I will test the robustness of the ordering in the baseline model by comparing a plausible alternative to that in Section 5. However, it is worth mentioning that a more plausible ordering of the variables is possible. For four variables, one could actually perform $4! = 24$ orderings of the variables.

One alternative would be to switch places between foreign price ($p^*$) and ($w$). This is a plausible ordering since wages are rigid. Thus, I would have the following ordering of the variables: 1) wages ($w$) 2) foreign prices ($p^*$) 3) exchange rates ($s$) and 4) export prices ($p$). Figures A3.12-A3.23 in Subsection A3.4 in the appendix illustrate the impulse responses of the export price to shocks in the exchange rate, foreign prices, and wages using the previously mentioned ordering of the variables.

The alternative ordering of the variables is labeled "Alternative" in the figures. For comparability reasons, the results under the baseline model are shown as well. I see that the results in the baseline specification are extremely robust to changing the order of the variables. The changes do not appear to be significant either. The responses of the export prices to the depreciation are by construction unchanged since the ordering of the exchange rate remains unchanged between the baseline and the alternative specification. Moreover, an increase in foreign prices is very robust to the two orderings of the variables. Finally, a shock to wages also implies rather robust results comparing the two models, with the exception of fabricated metal products, machinery and equipment in period 2. The response to a wage shock is negative for the baseline model for all horizons. However, for the alternative model, the response is initially negative and becomes positive after approximately two years. Thus, in summary, I can conclude that ordering wages first instead of foreign prices implies robust results to the three shocks in which we are interested.

# 7 Conclusions

The aim of this paper is to investigate the effects of shocks to exchange rates, exporting firms' wages, and foreign prices on export prices. I combine the micro and macro approach in the ERPT literature and model the implications for prices from the exporter's perspective. More specifically, the analysis is made with several assumptions concerning the currency in which prices are set and markup. I simulate a model and look at the effects of shocks to the exchange rate, wages, and foreign prices on export prices. This is done for four cases, namely LCP and PTM, PCP and PTM, LCP and CDM, and PCP and CDM. Further, I take a look at the data to see which theory predicts the dynamics of export prices the best. The empirical estimation method (i.e. VAR) is appropriate in that it takes into account the fact that all four variables are endogenous. Further, VARs make it possible to identify orthogonal shocks which affect all variables in the multivariate framework. For a shock to the exchange rate, the results from the impulse response analysis are in line with PCP and PTM for a majority of the included sectors. Foreign prices affect export prices in SEK. Comparing the results to the theoretical model, the responses are in line with PTM for all or parts of the included quarters for many of the included sectors. Finally, the results for wages are insignificant, which certainly raises the question of whether wages constitute a good proxy for a firm's marginal cost. However, proxies for marginal costs, especially for the time period covered by this paper (1975-2012), are hard to obtain. Thus, it seems that the exchange rate and foreign prices play important roles in the exporting firm's pricing decision.

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# Appendix

## A3.1 Data Plots

In Figures A3.1-A3.7, data on Swedish wages, foreign prices, exchange rates, and export prices are illustrated. All variables are in logs.

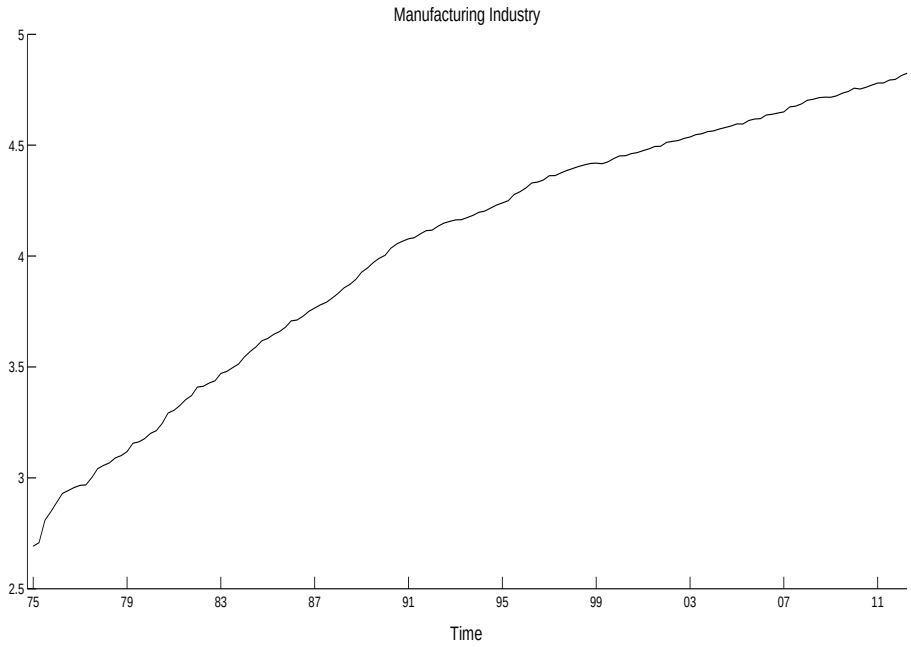


Figure A3.1: Hourly Earnings in the Manufacturing Industry, $w$

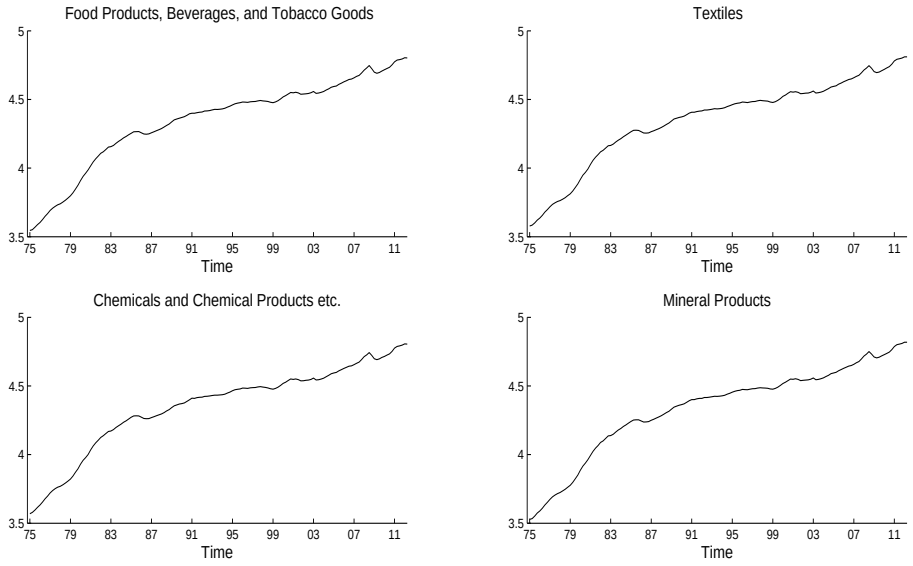


Figure A3.2: Trade-Weighted Foreign Price, $p^*$

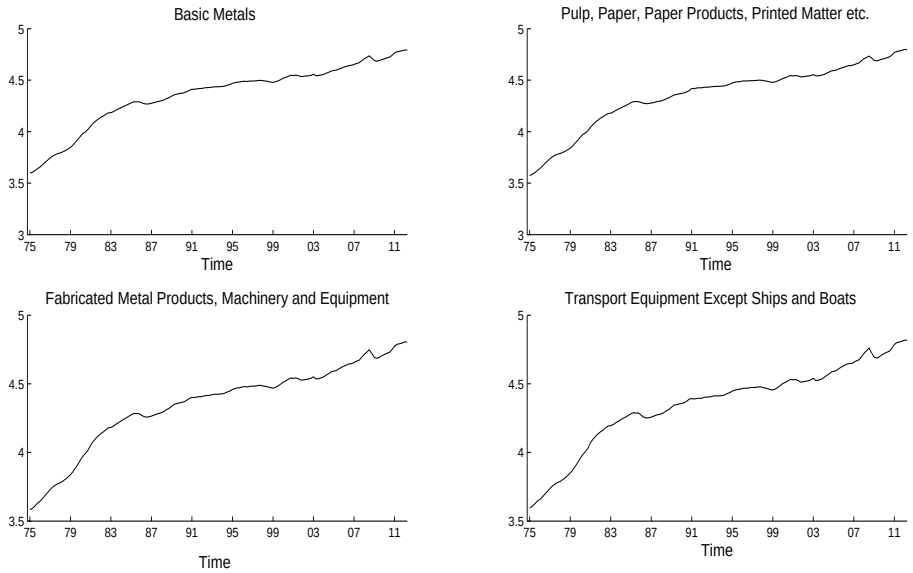


Figure A3.3: Trade-Weighted Foreign Price, $p^*$

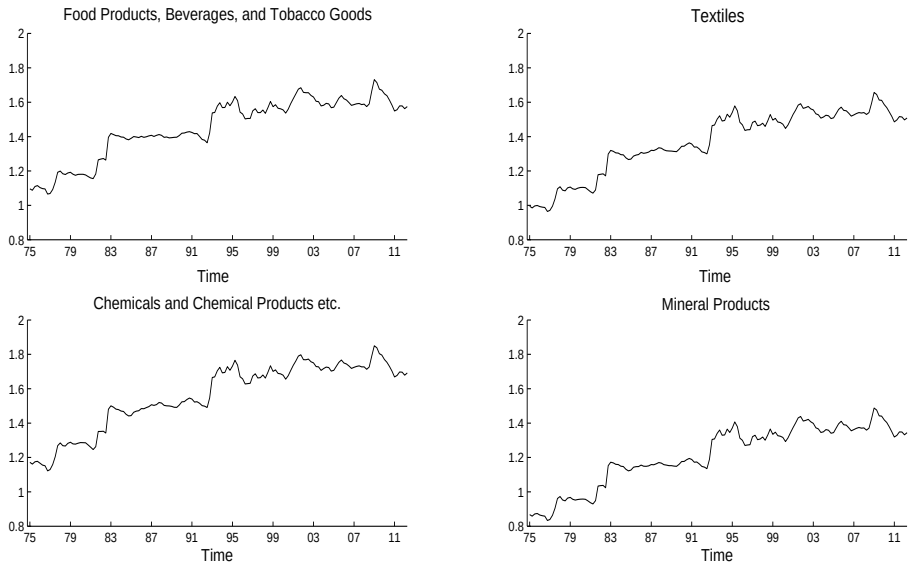


Figure A3.4: Trade-Weighted Exchange Rate, $s$

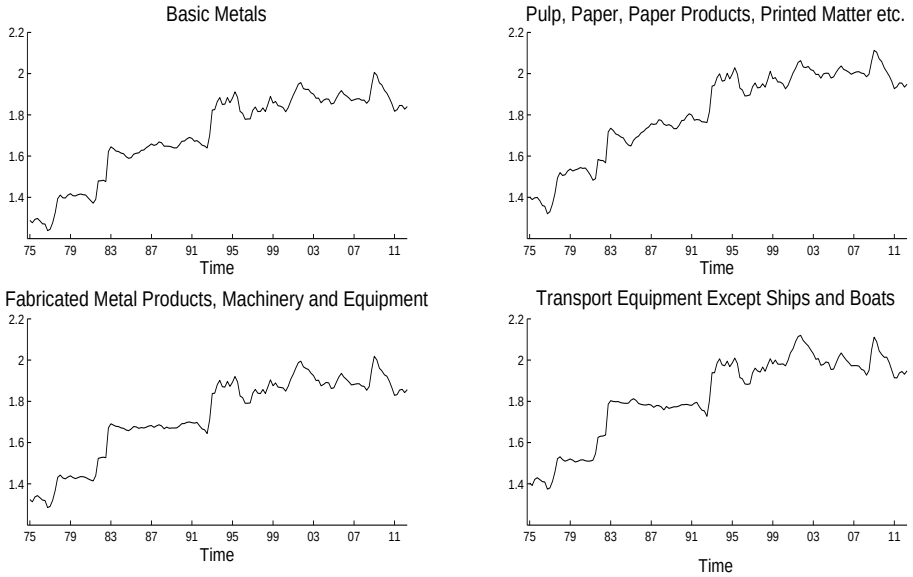


Figure A3.5: Trade-Weighted Exchange Rate, $s$

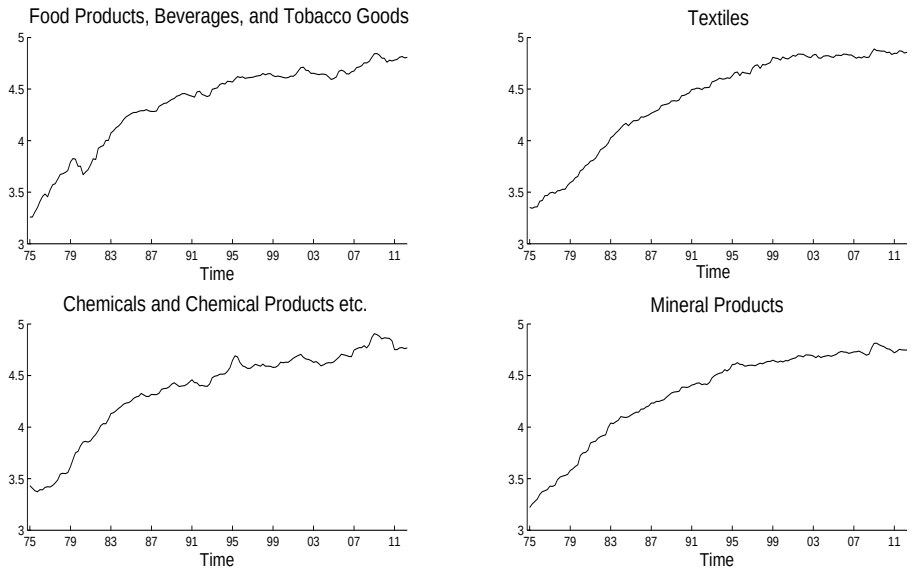


Figure A3.6: Export Prices, $p$

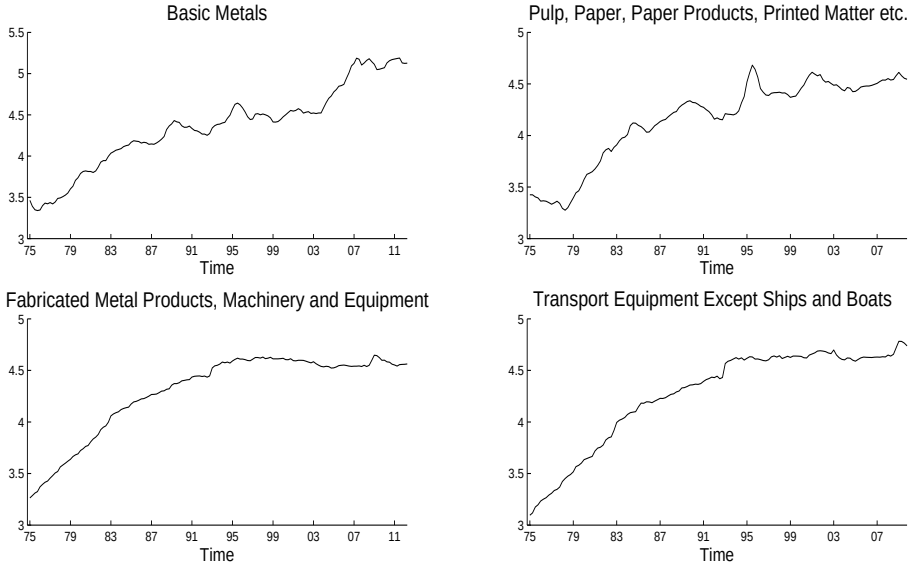


Figure A3.7: Export Prices, $p$

## A3.2 Data Appendix

Export prices are linked using data from the series SNI69, SPIN2002 and SPIN2007.

| SPIN2007 | SPIN2002 | SNI69 |
|---|---|---|
| 10-12 | | 31 |
| Food Products, Beverages, and Tobacco Goods | | Food, Beverages, and Tobacco Products |
| 13 | | 321 |
| Textiles | | Textiles |
| 21-22 | | 351-352 |
| Chemicals and Chemical Products etc. | | Chemical Products |
| 23 | | 36 |
| Other Non-Metallic Mineral Products | | Mineral Products |
| 24 | | 37 |
| Basic Metals | | Basic Metals |
| | 21+22 | 34 |
| | Pulp, Paper, Paper Products, Printed Matter | Pulp, Paper, Paper Products, Printed Matter |
| | and Recorded Media Matter | and Recorded Media |
| 25-33 | | 38 |
| Fabricated Metal Products, Machinery and Equipment | | Fabricated Metal Products, Machinery and Equipment |
| | 34+35 excl 35.1 | 3842-9 |
| | Transport Equipment Except Ships and Boats | Transport Equipment Except Ships and Boats |

Table A3.1: Export Price Indices for Different Price Indices Series and what Is Included in Them

| Variable | Source |
|---|---|
| Export Price Index | Statistics Sweden 1990 |
| Exchange Rates | The Central Bank of Sweden, Riksbanken |
| Producer Prices | United States, OECD, Main Economic Indicators |
| | Canada, OECD, Main Economic Indicators |
| | Norway, OECD, Main Economic Indicators |
| | Finland, Statistics Finland |
| | Denmark, OECD, Main Economic Indicators |
| | Germany, OECD, Main Economic Indicators |
| | Italy, Prometeia |
| | France, Eurostat, OECD Economic Outlook Database |
| | The Netherlands, International Financial Statistics (IFS) and Statistics Netherlands |
| | Belgium, OECD, Main Economic Indicators |
| | The United Kingdom, International Financial Statistics (IFS) and Eurostat |
| | Austria, International Financial Statistics (IFS) and OECD, Main Economic Indicators |
| | Switzerland, Swiss Federal Statistical Office |
| Wages | OECD Main Economic Indicators |

Table A3.2: Variables and Data Source. As a Proxy for Wages per Hour, Hourly Earnings for Blue-Collar Workers Is Used.

| Variable | Sector | Notation | ADF Test Statistic | P-Value |
|---|---|---|---|---|
| $p^{*Fbt}$ | Food Products, Beverages, and Tobacco Goods | T+I | −3.321 | 0.067 |
| $p^{*Tex}$ | Textiles | T+I | −3.188 | 0.091 |
| $p^{*Chem}$ | Chemicals and Chemical Products etc. | T+I | −3.246 | 0.080 |
| $p^{*Min}$ | Other Non-Metallic Mineral Products | T+I | −3.321 | 0.067 |
| $p^{*Met}$ | Basic Metals | T+I | −3.291 | 0.072 |
| $p^{*Pulppap}$ | Pulp, Paper, Paper Products, Printed Matter etc. | T+I | −3.314 | 0.067 |
| $p^{*Fabr}$ | Fabricated Metal Products, Machinery and Equipment | T+I | −3.320 | 0.088 |
| $p^{*Transp}$ | Transport Equipment Except Ships and Boats | T+I | −3.086 | 0.114 |
| $s^{Fbt}$ | Food Products, Beverages, and Tobacco Goods | 1) I and 2) T+ I | 1) −2.068192 2) −2.720 | 1) 0.2579 2) 0.2302 |
| $s^{Tex}$ | Textiles | 1) I and 2) T+ I | 1) −2.056 2) −2.600 | 1) 0.2630 2) 0.2830 |
| $s^{Chem}$ | Chemicals and Chemical Products etc. | 1) I and 2) T+ I | 1) −2.033 2) −2.462 | 1) 0.273 2) 0.3467 |
| $s^{Min}$ | Other Non-Metallic Mineral Products | 1) I and 2) T+ I | 1) −2.006 2) −2.703 | 1) 0.284 2) 0.237 |
| $s^{Met}$ | Basic Metals | 1) I and 2) T+ I | 1) −2.087 2) −2.386 | 1) 0.250 2) 0.386 |
| $s^{Pulppap}$ | Pulp, Paper, Paper Products, Printed Matter etc. | 1) I and 2) T+ I | 1) −2.001 2) −2.286 | 1) 0.286 2) 0.439 |
| $s^{Fabr}$ | Fabricated Metal Products, Machinery and Equipment | 1) I and 2) T+ I | 1) −2.135 2) −2.460 | 1) 0.232 2) 0.347 |
| $s^{Transp}$ | Transport Equipment Except Ships and Boats | 1) I and 2) T+ I | 1) −2.221 2) −2.434 | |
| $w$ | Manufacturing | T+I | −3.045 | 0.1236 |
| $p^{Fbt}$ | Food Products, Beverages, and Tobacco Goods | T+I | −2.574 | 0.293 |
| $p^{Tex}$ | Textiles | T+I | −0.483 | 0.983 |
| $p^{Chem}$ | Chemicals and Chemical Products etc. | T+I | −1.863 | 0.669 |
| $p^{Min}$ | Other Non-Metallic Mineral Products | T+I | −2.200 | 0.486 |
| $p^{Met}$ | Basic Metals | T+I | −2.848 | 0.183 |
| $p^{Pulppap}$ | Pulp, Paper, Paper Products, Printed Matter etc. | T+I | −2.307 | 0.427 |
| $p^{Fabr}$ | Fabricated Metal Products, Machinery and Equipment | T+I | −2.122 | 0.529 |
| $p^{Transp}$ | Transport Equipment Except Ships and Boats | T+I | −2.054 | 0.566 |

Table A3.3: Augmented Dickey-Fuller (ADF) Unit Root Test Using SIC for Choosing Lag Length, Max 13 Lags. Notation: I and T+I Correspond to an ADF Test with Intercept and Trend and Intercept, Respectively. The ADF Test Is for the Whole Period, i.e. 1975-2012 (or 2009 Depending on Data Availability).

## A3.3 Impulse Responses of Wages to a Depreciation

In Figures A3.8-A3.11, impulse responses of wages to a depreciation are depicted.

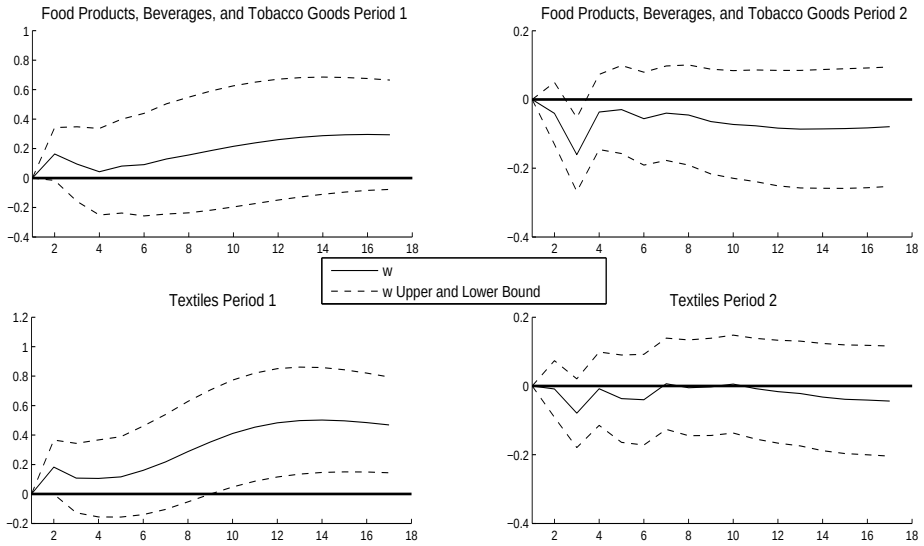


Figure A3.8: Impulse Responses of Wages to a Depreciation. Solid Lines Are the Responses of Wages. Dashed Lines Are 95 Percent Confidence Intervals.

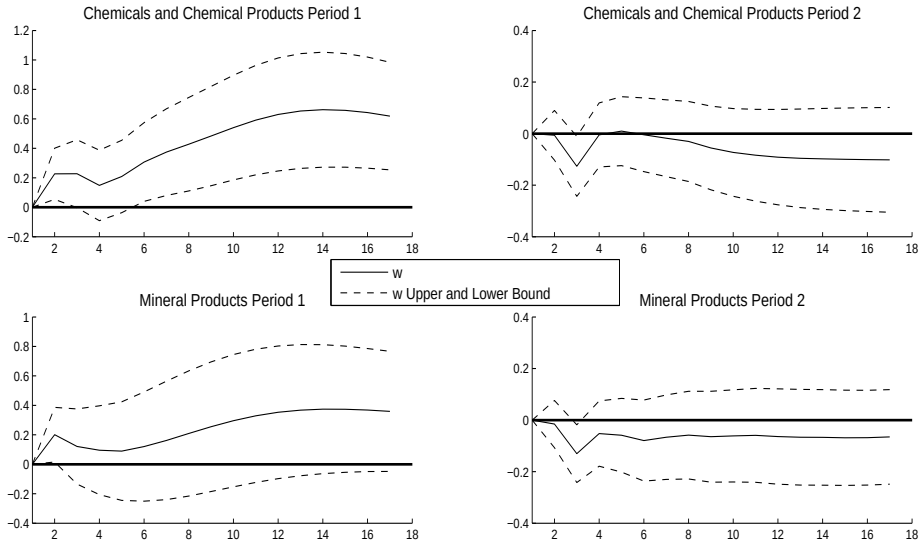


Figure A3.9: Impulse Responses of Wages to a Depreciation. Solid Lines Are the Responses of Wages. Dashed Lines Are 95 Percent Confidence Intervals.

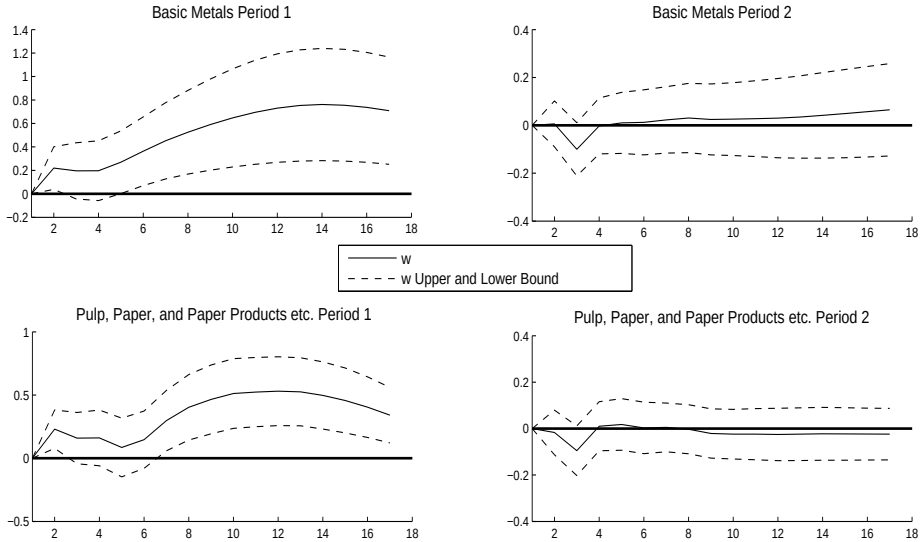


Figure A3.10: Impulse Responses of Wages to a Depreciation. Solid Lines Are the Responses of Wages. Dashed Lines Are 95 Percent Confidence Intervals.

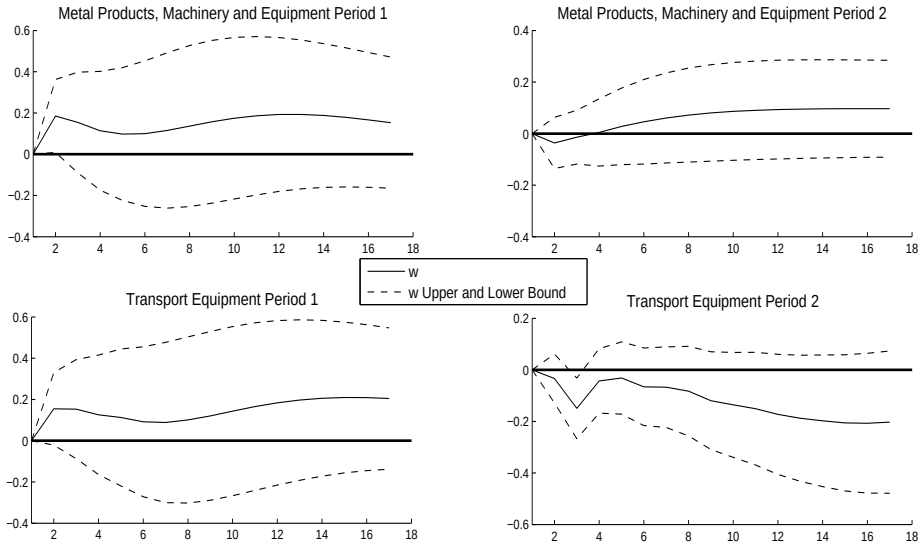


Figure A3.11: Impulse Responses of Wages to a Depreciation. Solid Lines Are the Responses of Wages. Dashed Lines Are 95 Percent Confidence Intervals.

## A3.4 Robustness Check

In this section, the impulse response functions to a shock in the exchange rate, foreign prices and wages for all sectors using a different identification scheme are presented.

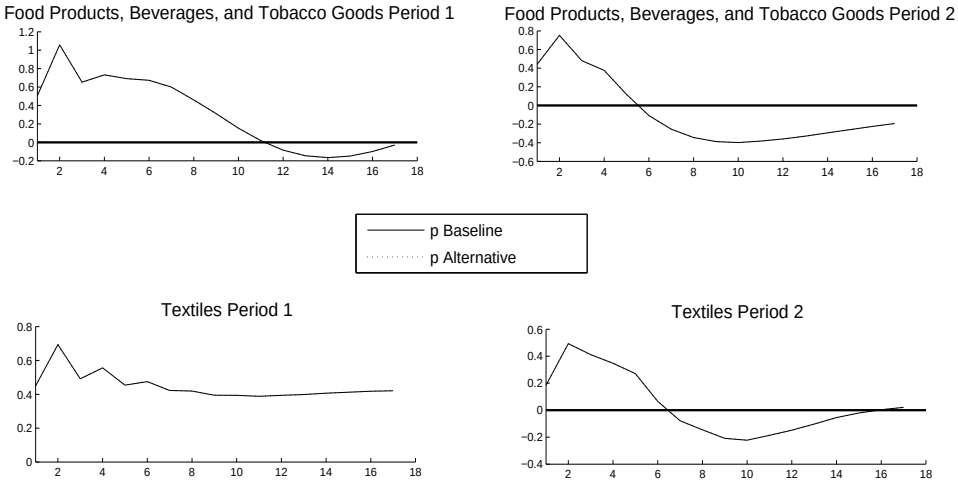


Figure A3.12: Impulse Responses of Prices to a Depreciation under Different Identification Schemes.

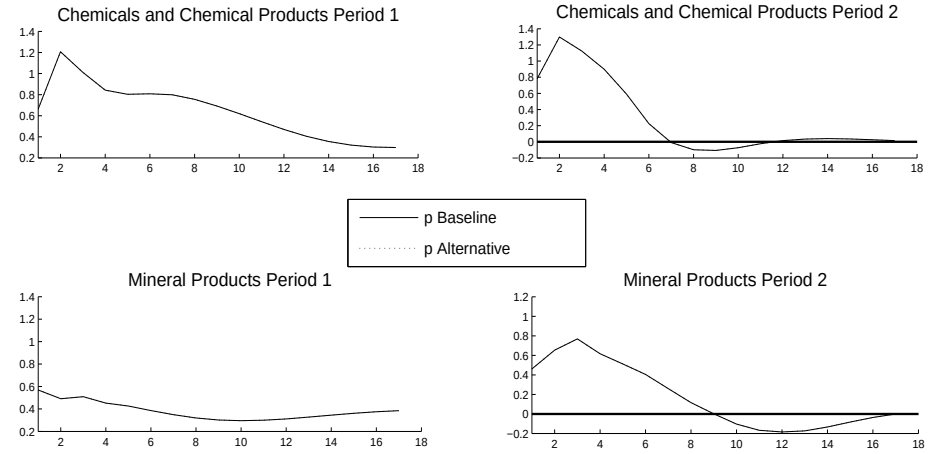


Figure A3.13: Impulse Responses of Prices to a Depreciation under Different Identification Schemes.

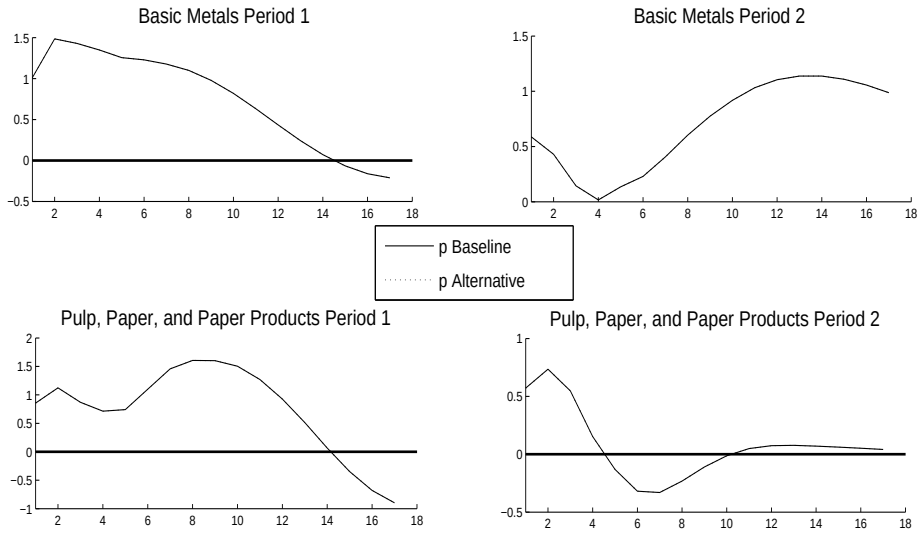


Figure A3.14: Impulse Responses of Prices to a Depreciation under Different Identification Schemes.

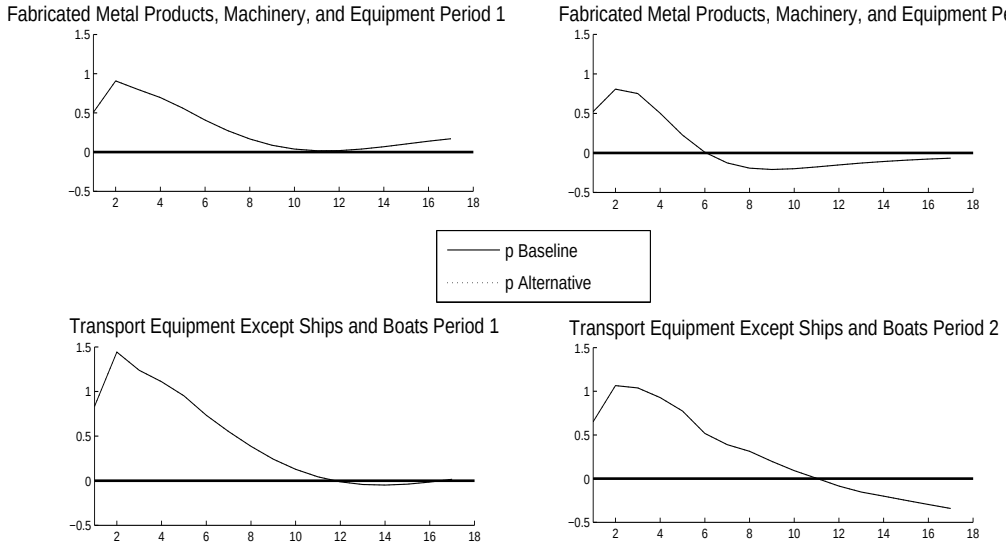


Figure A3.15: Impulse Responses of Prices to a Depreciation under Different Identification Schemes.

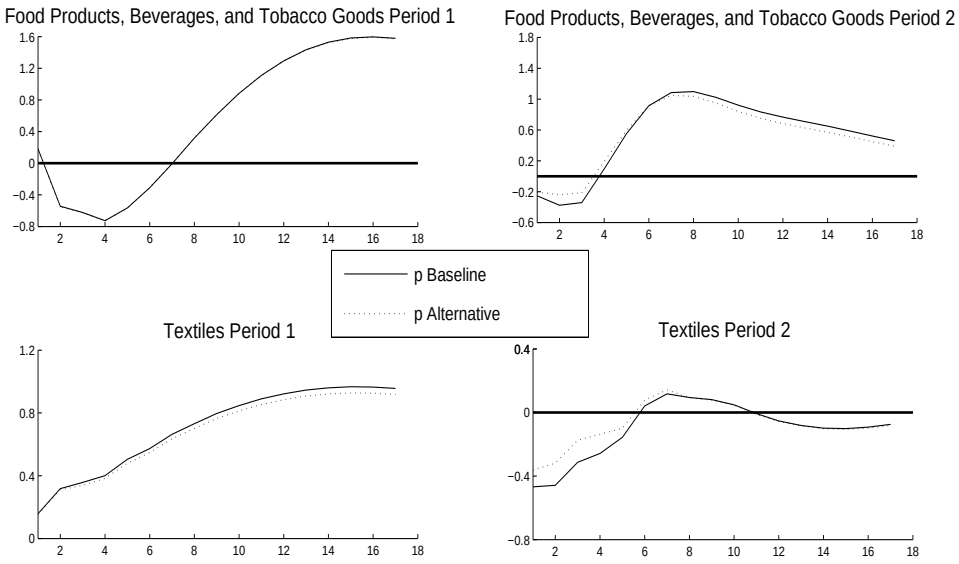


Figure A3.16: Impulse Responses of Prices to an Increase in Foreign Prices under Different Identification Schemes.

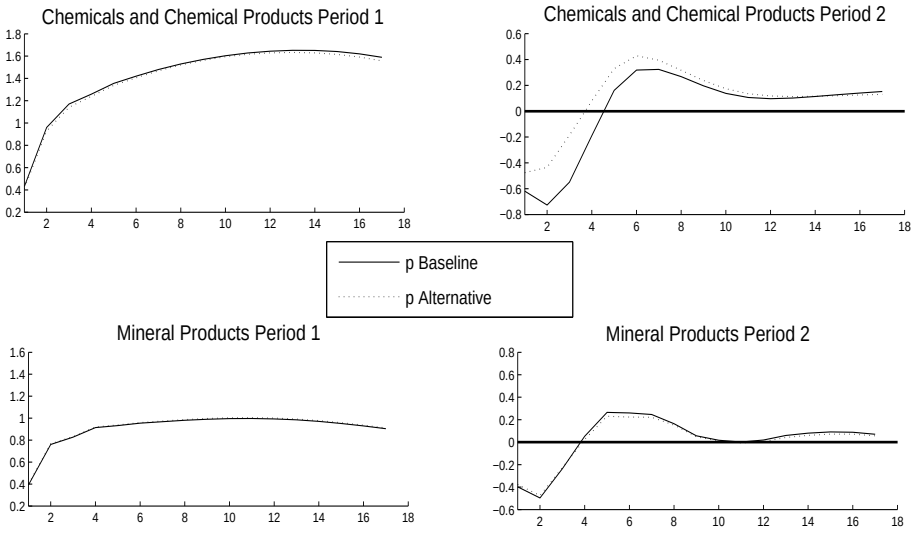


Figure A3.17: Impulse Responses of Prices to an Increase in Foreign Prices under Different Identification Schemes.

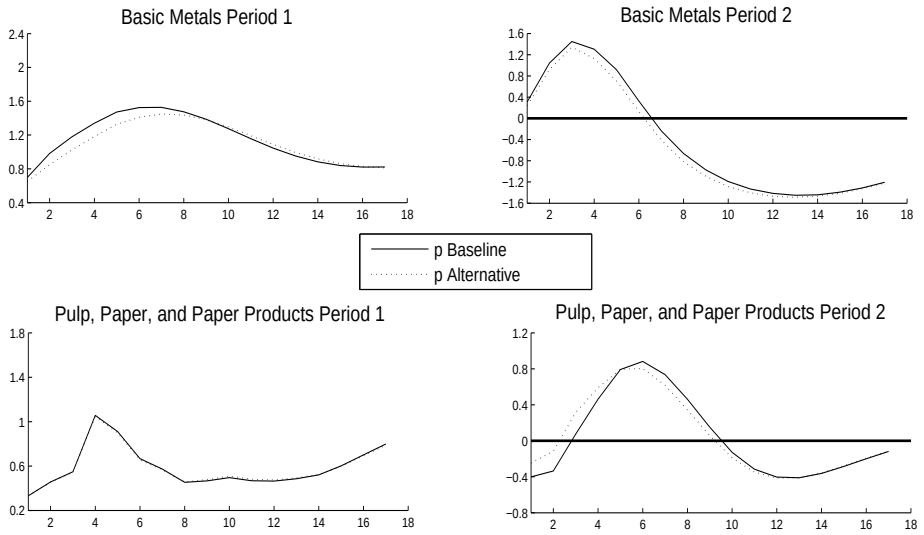


Figure A3.18: Impulse Responses of Prices to an Increase in Foreign Prices under Different Identification Schemes.

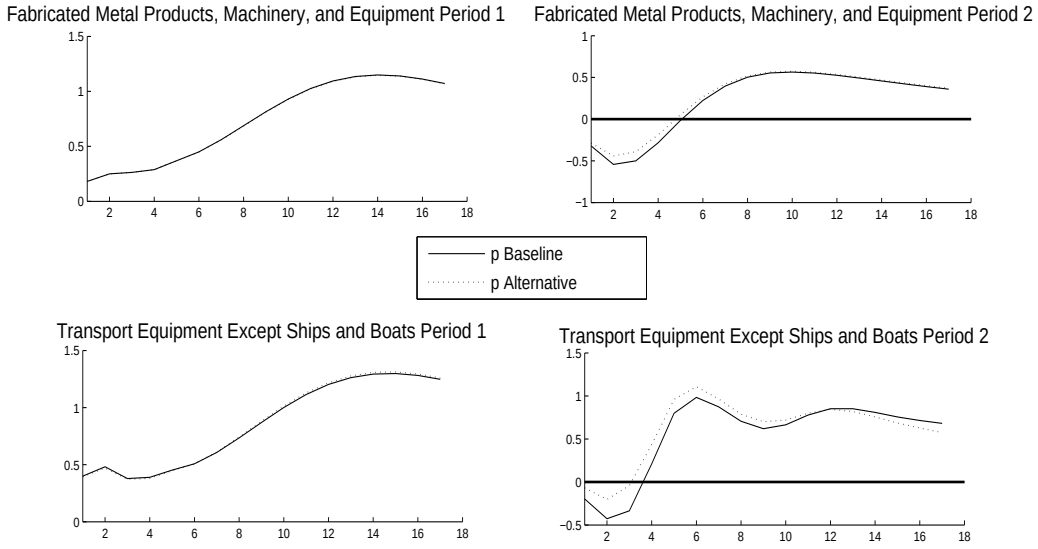


Figure A3.19: Impulse Responses of Prices to an Increase in Foreign Prices under Different Identification Schemes.

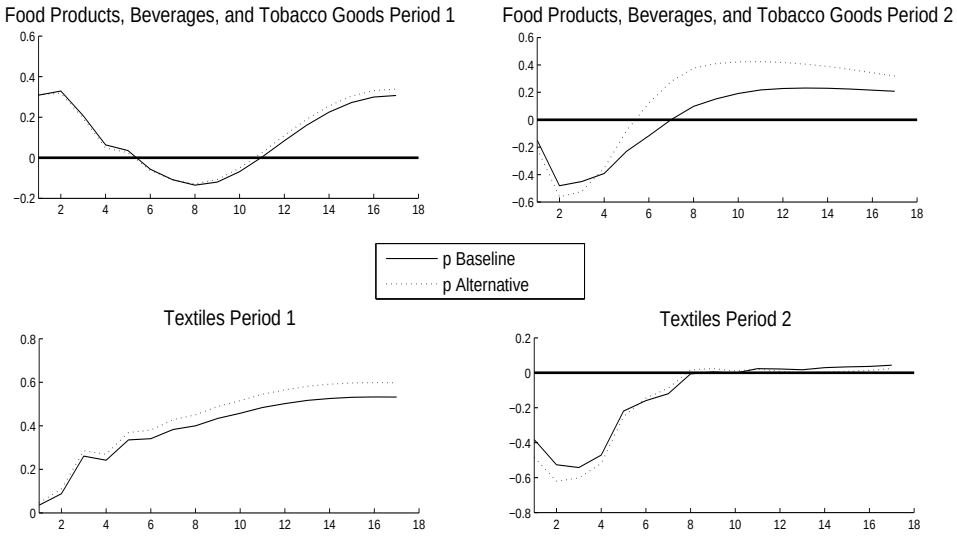


Figure A3.20: Impulse Responses of Prices to an Increase in Wages under Different Identification Schemes.

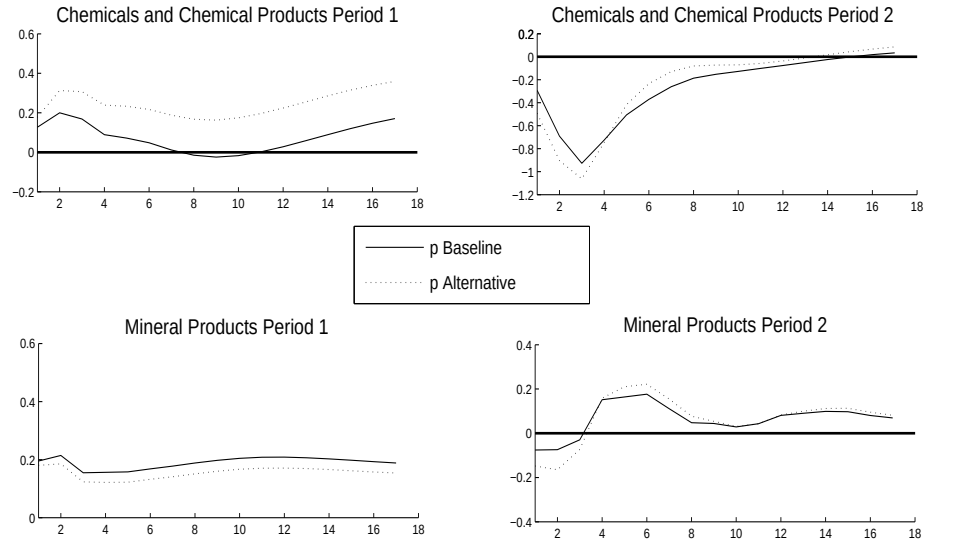


Figure A3.21: Impulse Responses of Prices to an Increase in Wages under Different Identification Schemes.

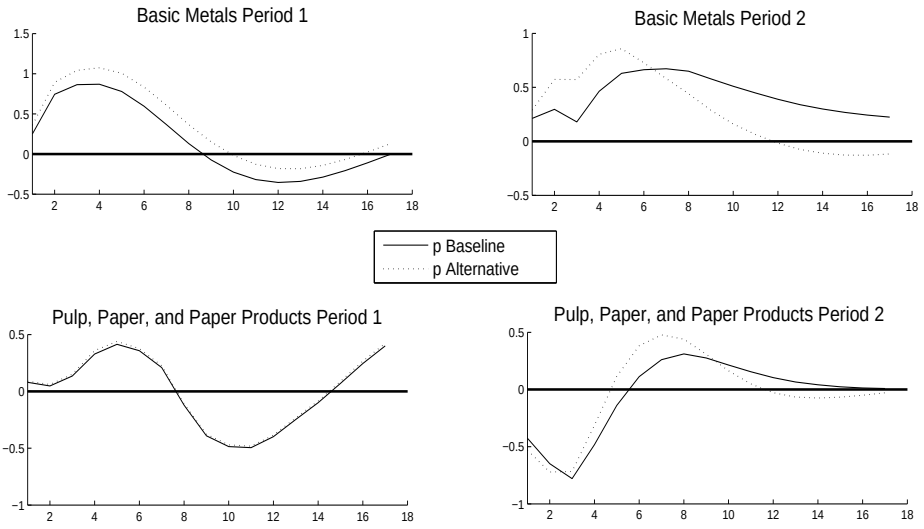


Figure A3.22: Impulse Responses of Prices to an Increase in Wages under Different Identification Schemes.

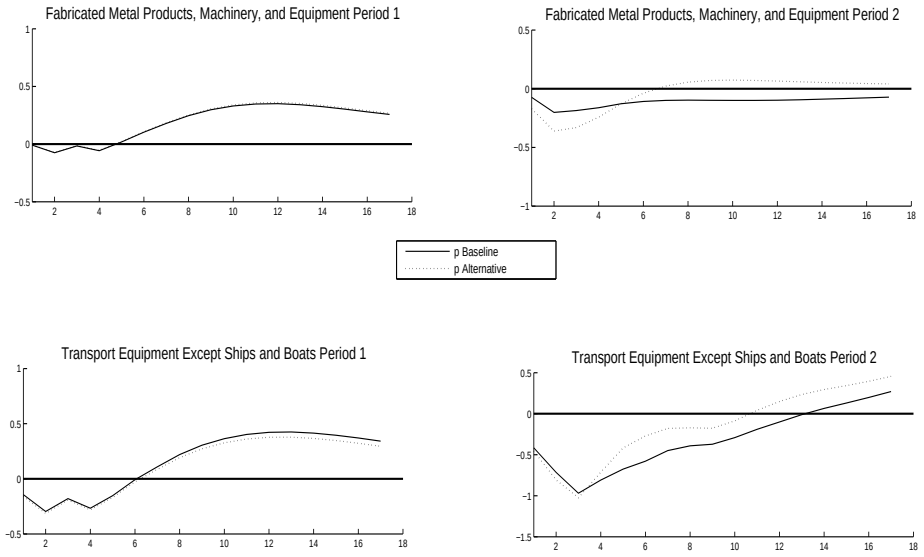


Figure A3.23: Impulse Responses of Prices to an Increase in Wages under Different Identification Schemes.

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