Exchange Rate Pass-Through to Canadian exports price:

An industry-based Approach

Research Paper for the Masters Degree in Economics

By

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August 2008

Acknowledgments

I would like to thank my supervisor Dr. Benoît Perron for his help and advices through out my research.

I also would like to reserve my deepest thanks and gratitude towards my brother and my parents for their support and encouragement.

Anything I have or I will ever attain will only be bestowed by God.

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Abstract

In this paper we studied the degree of Exchange Rate Pass-Through (ERPT) into the price of seven major crude and fabricated materials exported to the United-States. They include iron ore and scrap, paper and paperboard, crude oil and gas, petroleum and coal manufacturing, plastic and rubber, wood and aluminum. Our study covers the period going from Jan 2002 where the Canadian dollar started its appreciation to Apr 2007. We Used Vector autoregressions (VAR) technique and estimated the Cumulative Impulse Reaction Function generated. In the short term, we found evidence of null ERPT in the iron and petroleum and coal manufacturing industries and incomplete ERPT in the paper, crude petroleum and natural gas, wood and aluminum industries. ERPT is however more than complete for plastic and rubber. ERPT to US dollar exports price tends to rise over time. Our findings are consistent with previous empirical studies that found evidence of incomplete degree of ERPT to the US imports price.

Section 1

Introduction

The appreciation of the Canadian dollar versus the US dollar since January 2002[1] combined with the US economy slowdown had caused many concerns about the future of Canadian exports to the United-States, destination of around 85 percent of Canadian exports. Hence, an understanding of how exchange rate fluctuations affect exports price is important for a number of reasons. First, Exchange Rate Pass-Through measures Canadian goods competitiveness in the US market. Second, the degree of Exchange Rate Pass-Through to exports price affects the domestic demand and the balance of payment. Therefore, it has implications on monetary policy. Last but not least, understanding Exchange Rate Pass-Through gives insights about exporting firms' market power in particular industries.

The purpose of this study is to determine the extent to which Canadian dollar appreciation affects the price of Canadian top crude and fabricated materials exported to the United-States. We use the concept of Exchange Rate Pass-Through to describe how exports price labeled in US dollar will move with the Canadian dollar appreciation. If the US dollar exports price (or equivalently imports price paid by the US) increases one-to-one with the appreciation of the Canadian dollar, we say that Exchange Rate Pass-Through (ERPT) is complete. If however it remains unchanged, there is no ERPT. If it increases less than proportionally, ERPT is incomplete.

At this state of the theoretical discussion, two questions appear of special interest to be answered in this study. The first one concerns the factors determining the degree of ERPT. The second question is the degree of ERPT to exports price. Because of the potential diversity of pass-through between industries, we will be interested in the degree of ERPT on an industry-basis.

Empirical work found evidence of incomplete ERPT especially in industrialized countries. From one perspective, ERPT is explained from a macroeconomic perspective. According to this perspective, ERPT declines in stable economies with low inflation and low exchange rate volatility, (See Capma and Goldberg (2005) and Khundrakpak(2007))

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[1] See graph (2)

and with high trade integration.(Vigfusson, Sheets &Gagnon (2007)). The second is a micro perspective. Accordingly, Pricing-To-Market, price discrimination and imperfect competition are the main factors determining the degree of ERPT (Krugman (1986) and (Dornbush (1987))

Our paper is built on the well-known Pricing-To-Market literature (see Krugman (1986), Abali (2004) Campa& Goldberg (2005) and Yang (2007)). Accordingly, ERPT will be incomplete when home currency appreciates because exporting firms will lower their markup over cost of production in order to prevent a large increase in destination currency exports price and hence preserve foreign demand. This study is also inspired by Rockerbie (1992). He estimated ERPT for four aggregate industrial exports sectors over the period 1971:1 to 1990:2 using a VAR technique. He found full pass through for the food and crude materials sectors and incomplete pass through for fabricated and products sectors.

This paper attempts to study Exchange Rate Pass-Through to exports price of crude materials and fabricated materials included in the top ten merchandise exports to the United States. Crude materials group includes iron ore and scrap, crude petroleum and natural gas. Fabricated materials group includes paper and paperboard, plastic[1], petroleum and coal manufacturing, wood and aluminum. Our study covers the period extending from Jan 2002 where the Canadian dollar appreciated to Apr 2007.

The VAR technique is particularly suitable to studying the time path of the response of exports price to nominal exchange rate appreciation. It allows all variables to be endogenous and hence trace the dynamics between all series. Cumulative Impulse Reaction Function will be estimated to trace the magnitude of the response of exports price to an exchange rate disturbance over time.

The remainder of the paper is organized as follows. Section 2 gives a review of the empirical work that studied ERPT to trade prices. Section 3 presents the theoretical model on which we base our empirical analysis. Section 4 discusses the sources and data construction, section 5 discusses estimation results. Section 6 concludes.

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[1] According to Stat Can classification for international merchandise trade, plastics and rubber are aggregated into one major group.

Section 2

Literature review

The increased openness of most economies with the incidence of large fluctuations in nominal exchange rates has evoked interest in the Exchange Rate Pass-Through relationship with prices. Most of the empirical studies have focused on ERPT to import, producer and consumer prices. However, limited studies investigated ERPT to export prices. A growing body of the empirical work on ERPT has found evidence of decline in ERPT in number of countries, specially industrialized countries. However, current literature shows disparity in the degree of ERPT not only between countries but also between different industries. Some studies go even further by asking about the symmetry of ERPT in periods of appreciation and depreciation. In this section we review the literature on the factors determining ERPT to trade prices as well as evidence of asymmetry of the ERPT behavior.

2-1 What determines Exchange Rate Pass-Through?

A growing body of the literature on industrialized economies beginning in the late 1980's found evidence that ERPT is incomplete. Accordingly, factors affecting ERPT represent an important field of investigation in academic research. Related literature gives two approaches: The first approach is on a macro level and the second is on a micro level. We will discuss these two approaches and add other factors non related to these two approaches.

On the Macro-level, Campa and Goldberg (2005) carry out cross-country and time series study on the degree of ERPT into import prices of 23 OECD countries using quarterly data from 1975 through 2003. Across time, they found that Pass-through has declined for 15 of the 21 countries, and has increased for the other 6 countries. However, across countries, they found the average of pass-through elasticities across the OECD countries is approximately 46% over the short term and approximately 64% over the longer term. The United States has among the lowest pass-through rates, at approximately 25% in the short run and 40% over the longer run while Germany has the highest pass

through at 60% and 80% in the short term and long term respectively. According to this study, shifts in the degree of ERPT could arise either because of changes in industry competitive conditions or changes in the composition of products in a country's import bundle. They also study the degree of ERPT to disaggregate import prices for five product categories: food, energy, raw materials, manufacturing, and non manufactured products. They found inequality of pass-through coefficients across theses industries. They argue that with different pass-through elasticities across industries and changes in imports bundle, aggregate ERPT will change through time. For example, the decline of energy proportion and the rise in the share of manufactured products in the import bundle can explain the recent pass-through changes into import prices among OECD countries. On the other hand they related cross-country differences to macroeconomic aggregates. Most notably, pass-through into import prices is lower for countries with low average inflation and low exchange rate variability. Khundrakpam (2007) elaborates on macroeconomics aggregates in determining ERPT. According to this study, the lower the rate of inflation and its volatility, the lower the pass-through will be. Improved credibility and effectiveness of monetary policy in maintaining a low inflation will lower the pass-through, as inflation is maintained at a low level. Firms are thus less keen to change their prices following shocks on cost, as they believe that monetary policy will be successful in stabilizing prices. It also adds that a high degree of openness of an economy (larger presence of imports and exports) will lead to higher degree of ERPT.

Similarly Ferreira & Sansó (1999), study the extent of ERPT to Brazilian exports of manufactured goods with quarterly data for the period 1977 to 1996. In this study, time series were split into two sub-samples. The estimates of ERPT varied from 30% in the first period going from 1978:3 - 1985:4 to close to zero, in the second period 1986:1 - 1996:4. Results give evidence that pass-through coefficient has changed over time, being much higher in the first period than in the second period of pronounced macroeconomic instability and high exchange rate volatility. According to the author, the reason is that exporters will choose to maintain their prices in foreign currency invariant to changes in the exchange rate that are perceived as transitory in order to preserve their shares in foreign markets. For this reason, increases in the variability of the exchange rate may be accompanied by a reduction in the coefficient of pass-through.

On the micro level, the most well-known factors affecting ERPT are the Pricing – To- Market theory (PTM), imperfect competition and demand price elasticity.

Krugman (1986) introduces the concept of Price to Market (PTM) to explain the decline of ERPT. He defines it as whenever import prices fail to fall in proportion to the exchange rate appreciation. He found that the appreciation of the dollar since 1980 had been absorbed by European exporters in a rise of their prices to the US compared with prices in other markets. Hence, US imports price fell too little with US dollar appreciation. He explains this behavior by monopolistic price discrimination and imperfect competition in the market.

Dornbush (1987) empirical study also covers the period of appreciation of the US dollar in 1980-1985. According to Dornbusch, in an open economy where labor is the only input, with a stronger currency foreign labor cost in US dollar had to decline and therefore pass through to US dollar imports price should be complete. He argues that in the case of homogenous goods, ERPT will be complete. However, if goods are differentiated, pass through into cost of production and prices will depend on the market structure and the relative market share of domestic and foreign firms. In a competitive market where firms are price takers, imports dollar price will decline, however and in an imperfectly competitive market or oligopolistic market, firms are price makers and set their prices in a strategic way, thus the weak degree of ERPT

According to Yang (2007), PTM depends on the curvature of the perceived demand price elasticity. If the perceived demand elasticity is constant, pass through of exchange rate to import price is complete. However, when demand elasticity becomes more elastic as price increases, there will be a PTM. In case of domestic currency appreciation, exporting firms will adjust their markup to prevent a full pass through of the exchange rate shock to the importing currency price, and hence maintain their market share. Demand price elasticity will depend on macroeconomic factors like credibility in monetary policy and on microeconomic factors like market competition

Other factors affecting ERPT

Vigfusson, Sheets& Gagnon (2007) analyze prices charged on exports to the U.S. market. It finds that exchange rate sensitivity of export prices is significantly affected by the trade or/and region partner. For the Asian region, exports price sensitivity to exchange rate movements was strongly related to the effects of the Asian financial crisis. For Canada, given increased trade integration and dependence on U.S. demand (85 %of the country's exports go to the United States) exports price seems very sensitive to exchange rate movements. The sensitivity of exports price depends however on the direction of moves in the exchange rate. Exporters cut their prices in the U.S. market when the U.S. dollar is strong but are hesitant to raise their prices when the dollar is weak. Another finding is that the prices that foreign exporters charge in the U.S. market is more responsive to the exchange rate than it is for other markets on average. In this respect, the United States is special. The US dollar plays a unique role in the determination of global traded goods prices, reflecting both the international role of the dollar and the centrality of the U.S.A in the marketplace.

An (2006) referred to Menon (1995) statement: "*As the significant differences in the estimate of pass-through obtained by different researchers studying the same country, commodity and time period highlight the importance of choice of data and methodology*". He made a survey of the literature on ERPT empirical studies, the data, the methodology and the key findings. He argues that ERPT is related to which of the three econometric techniques is used: these techniques are single-equation regression techniques (OLS), Vector AutoRegressive VAR and Vector Error correction Model (VECM). Using OLS ignores the fact that a large number of series is non-stationary. Moreover, it assumes that there are no endogenous variables. Thus, the estimation could suffer from simultaneity bias especially due to the endogenous determination of exchange rates and prices. The second technique is VAR in first difference. It solves endogeneity problem. However, differencing throws away information which may cause the results to lack statistical significance. Finally, VECM model is a good approximation to the data generating process, and cointegration captures the long term equilibrium relationships among the

variables. However, it is greatly doubted whether it is possible to determining the correct rank or identifying the true cointegration relations.

2-2 Is Exchange Rate Pass-Through behavior symmetric?

Faruqee (2006), studies ERPT from 1990 to 2002 along the pricing chain: factor input prices ((i.e. wages *w*), trade prices (import and export prices), producer prices and consumer prices for the euro area, the United States, Japan, the United Kingdom, and Canada. He found that pass-through to trade prices is incomplete and tends to rise over time. The pattern of pass-through in trade prices shown in table (1) suggests a significant degree of disparity between countries as well as asymmetry in the pass through to imports or exports prices. This is consistent with the findings of Campa and Goldberg (2005).

Khundrakpam (2007) studies the ERPT to domestic prices in India during the post-economic reforms initiated since the major devaluation of July 1991. He finds that the estimated pass-through coefficients are higher for appreciation than for depreciation. He investigates the main causes of asymmetry of ERPT in periods of appreciation and depreciation:

1-Binding quantity constraints: an appreciation of the importing country's currency would increase its demand, but exporting firm capacity constraints limit expansion of sales. Thus, exporting firms raise their mark-ups to keep import prices in the importing country's currency fixed hence the volume of sales remain unchanged. In the case of depreciation, the same capacity constraint is not binding even when firms may reduce their mark-ups to absorb part of the impact of depreciation, imports price in home currency could still rise. Thus, the pass-through is higher for depreciation than for appreciation

2-Market share objective: when firms are building up market share, appreciation in the currency of the importing country will allow the firms to lower import prices to increase their market share while maintaining their mark-up. But in the case of depreciation, the exporting firms will reduce their mark-ups to maintain their market shares. Thus, pass-through would be higher for appreciation than for depreciation

Yang (2007) studies the symmetry of pass-through of the US dollar between its appreciation in the early 1980s and its depreciation after1985. His estimation results

show that in general there has been no change in the pass-through behavior to aggregate import price after 1985 when the dollar started to depreciate.

Osbat and Wagner (2006) estimate ERPT to euro area manufacturing imports prices at the sectorally disaggregated level. They find very heterogeneous results across sectors, for immediate responses, for the dynamics and for the long-run response. They find evidence of heterogeneity of ERPT across sectors. For eight sectors there found evidence of complete ERPT: computing and office machinery, electrical machinery, fabricated metals, plastics, precision instruments, radio and TV equipment, textiles and wearing apparel. For chemical products and motor vehicles, they found no ERPT and for the machinery and metals sector long-run ERPT was incomplete.

Rockerbie (1992) studied ERPT to four industrial exports sectors in Canada in the period covering 1971q1 to 1990q2 where Canadian dollar was depreciating. He found evidence of full ERPT for food products and crude materials sectors. Pass-Through was however 70% and 67% for fabricated and end products sectors respectively. On average he sums up that global ERPT was around 80%. He finally concludes that international competitiveness of Canada's exports - measured by the degree of ERPT- is increasing. According to Rockerbie, this result is in great contrast to previous results by Spitaeller (1980) and Robinson (1979) who found ERPT in the 1970's to be 5% and 11% respectively.

We sum up from this section that in the aggregate level, a wide body of the literature found evidence of incomplete ERPT to trade prices. The main factors affecting ERPT are macroeconomic variables, PTM and trade integration. The large majority of the literature study ERPT to imports price and limited are the studies on ERPT to exports price. Faruqee (2004) and others have found evidence of different degree of ERPT to imports and exports prices. There is also evidence of disparity in the extent of pass through between different sectors and industries. The behavior of ERPT also depends on the direction of the movements of the exchange rate and on the trading partner.

In the next section, we discuss the theoretical model upon which this paper is built. Yang's (2007) model on demand price elasticity is presented along with the Pricing To Market model (PTM).

Section 3

Theoretical model

The starting point for the analysis is a simple mark up price model. The domestic firms set their export price PX in home currency as a markup λ on their production cost CP in home currency

$$PX = \lambda\, CP$$

Consider two economies; home and the United-States. Following home currency appreciation, exporting firms have four alternatives. In the first alternative, firms possessing certain market power decrease their markup of price over cost by the same degree of appreciation. Home currency exports price will decrease and exports price in US dollar remains unchanged. In this case there is no Exchange Rate Pass-Through. The second option, exporting firms maintain home currency exports price and hence exports price in US dollar increases by the same degree of the appreciation .In that case there is a complete Exchange Rate Pass-Through. The third alternative, firms lower home currency price less than proportionally then US dollar price will rise but less than proportionally i.e. there is partial Exchange Rate Pass-Through. Finally, firms could raise home currency price and the dollar price will become more than proportionally higher.

In the first alternative, exporting firms adjust their markup to prevent a decrease in US demand and hence profits remain unchanged. With either complete or partial ERPT exporting firm's profit decreases since US dollar export price increase will lower US demand.

Demand price elasticity

According to Yang (2007), the degree of markup response to an appreciation depends on the shape of foreign demand. This latter helps understanding the degree of ERPT to our industries in section 5

Without loss of generality, the following identity holds for a Canadian firm exporting to the USA: p is Canadian dollar export price, p* is US dollar export price and e is the nominal exchange rate (Cdn dollar per unit of US dollar).

$$\frac{p}{e} = p*$$

When Cdn dollar appreciates, either p or p* or both will change.

Suppose that Canadian exporter sets its price in US dollars for its exports to the US market and p*(q) is the inverse demand function, c (q) is the exporting firm cost function In a competitive market, the profit of the exporting firm in terms of Canadian dollar Π (q) is

$$\Pi\ (q) =\ e\ \ p*(q)\ \ q - c(q) \qquad (1)$$

As we assumed competitive market, (1) could be written as:

$$p*(q)\ \ q = \frac{c(q)}{e}$$

Assuming constant marginal cost mc, the profit maximizing condition becomes:

$$p*(1+\frac{1}{\eta}) = \frac{mc}{e} \qquad (2)$$

Where η is the demand elasticity facing the exporter and $\dfrac{1}{1+1/\eta}$ is the markup over marginal cost. The elasticity of import price with respect to the exchange rate, known as the degree of Exchange Rate Pass-Through is:

$$\tau = \frac{d \ln p*}{d \ln e} = -\left[\frac{\eta+1}{\eta+1-(d \ln \eta / d \ln p*)}\right] \qquad (3)$$

Equation 3 indicates that ERPT depends on how price affects the demand elasticity, i.e. *the elasticity of the demand elasticity with respect to exports price labeled in US dollar;*

$\dfrac{d\ln\eta}{d\ln p*}$ (see Abali 2006). When demand elasticity is constant, (i.e. $\dfrac{d\eta}{dp*}=0$), pass through to export price in US dollar (import price perceived by USA) is -1. When Canadian dollar appreciates by 1 % ($e\downarrow$), exports price labeled in US dollar increases by 1% or complete ERPT.

After determining how firms react to home currency appreciation, we go back to the markup pricing model proposed by Hooper and Mann (1989).

Markup price model

The domestic firms set their export price PX in home currency as a markup λ on their production cost CP in home currency

$$PX = \lambda\, CP \qquad\qquad (4)$$

Where markup (λ) is a function of foreign demand pressure in the domestic market and of international competition pressure. Demand pressure is proxied by the capacity utilization index and the competition pressure is proxied by the difference between foreign price labeled in the domestic currency and the domestic production cost.

$$\lambda = (CAP)^{\alpha}(P*^{\delta}\ E^{\beta})/(CP)^{\xi} \qquad\qquad (5)$$

Where
CAP is he capacity utilization index
P* is the foreign price
E is the price of home currency per unit of foreign currency

By substituting (5) in (4), we get
$$PX = (CAP)^{\alpha}(P*^{\delta}\ E^{\beta}/CP^{\xi})\ CP \qquad\qquad (6)$$

Taking the logarithm of equation (6) and denoting logarithms of the variables as lower-case letters, the export equation becomes:

$$px = c + \alpha\ cap + \delta p^* + \beta e + (1-\xi)cp + u \qquad (7)$$

We can rewrite (7) as

$$px = \beta_0 + \beta_1 cap + \beta_2 p^* + \beta_3 e + \beta_4 cp + u \qquad (8)$$

Where u is the error term

In equation (8), β_3 measures the proportion of exchange rate change reflected in home currency export price. It reflects how exporting firms adjust their markup price over cost of production following exchange rate movements. By definition, ERPT is the degree of transmission of exchange rate changes into destination currency traded prices and hence in our case into US dollar export prices. We derive it from (8)

$$-\frac{\partial \ln(PX/E)}{\partial \ln(E)} = -\frac{\partial(\ln PX - \ln E)}{\partial \ln E} = -\frac{\partial \ln PX}{\partial \ln E} + 1 = (1 - \beta_3)$$

So $(1 - \beta_3)$ is the ERPT and β_3 is the other side of the coin that is the PTM coefficient.

Following the Canadian dollar appreciation, exporting firm who possesses some market power, will decrease its profit margin one to one with the appreciation so that US price paid by the US importer (px/e) remains constant; β_3=1 , $(1 - \beta_3)$=0; there is no ERPT. Thus, exporting firm will prevent a loss of the US market. On the other hand, if exporting firm maintains its Canadian dollar exports price, imports price facing the US importer will increase by the same amount of the appreciation; β_3=0 and $(1 - \beta_3)$=1; there is complete pass-through. Between these two cases, we have 0< $(1 - \beta_3)$ <1 or partial ERPT. However, in some case we could have β_3<0 or $(1 - \beta_3)$ >0. This could happen if the demand curve is more convex than a constant elasticity of substitution function (Abali 2006).

In the next section, we present the data sources and data construction. In section 5, we complete our model construction and define our variables. We will then test the degree of ERPT $(1 - \beta_3)$ (or equivalently PTM β_3) to US dollar exports price of seven major industries exported the United States. We use an unrestricted Vector Autoregressive (VAR) technique and estimate the Cumulative Impulse Reaction Function

to trace the time path response of exports price to exchange rate and other explanatory variables shocks.

Section 4

Data Construction

Canada specific data were retrieved from Statistics Canada (CANSIM database) and Bank of Canada. US specific data were retrieved from Bureau of Labor Statistics and the Federal Reserve Board. The study covers the period from Jan 2002 to Apr 2007. The choice of this period was restricted by the following limitations: 1- Canadian export price data series covering the period from Jan 1997 to Mar 2007[1] was discontinued and doesn't provide the disaggregated variables needed in this study. 2 - Data series providing disaggregated variables starting in 1992[2] is discontinued and ends on March 2001 which creates a gap of 9 periods if we use it with the series covering Jan 2002 to April 2007[3]. 3- This period is very convenient for the purpose of this study as it entirely covers the period where the Canadian dollar was appreciating.

Our industry choice is based on the top ten merchandise exports to the United States in 2006, published in Canada's State of Trade, Trade and Investment Update - 2007[4] (see graph 1). For the purpose of this paper, we focus on industries belonging to crude materials and fabricated materials. The sorting was also based on the availability of the disaggregated data and the possibility of matching data series classified as follows:
Exports price is classified according to the Standard International Trade Classification (SITC) Revision 3. Industrial Producer Prices (IPP) and Industrial Capacity Utilization Index are based on North American Industry Classification System (NAICS). US Industrial Producer Index (IPI) is based on industry groups' classification which is conciliated with NAICS classification. The conciliation was accurately done as possible as we can and is displayed in tables (2) and (3)

Time series were retrieved seasonally adjusted except for US IPPs. We used Holt–Winters seasonal smoothers to deseasonalize these time series. All variables are in log, except for interest rate. We chose Dec 2003 as base year (2003m12=100).

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[1] CANSIM, series no 228-0044
[2] CASIM, series no 228-0004
[3] CASIM, series no 228-0050
[4] Department of Foreign Affairs and International Trade Canada, (DFAIT)

Section 5

Empirical analysis

The model

Explanatory variables are derived from the reduced form of a simple demand-supply model set out in Rockerbie (1992). The model is presented as follows:

$$Q_d = f(PX, US\_IPI, USP, e)$$
$$Q_s = g(PX, CDP, CAP, e)$$

$$PX = h(US\_IPI, USP, CDP, CAP, e)$$

Q_d : Demand for Canadian products

Q_s : Supply for Canadian products

PX: Exports price in Canadian dollar

US_IPI: US Industrial Production Index captures US demand

USP: US Industrial Producer Price in US dollar

CDP: Canada Industrial Producer Price in Canadian dollar captures domestic cost of production

CAP: Capacity Utilization rate captures the ability of Canadian suppliers to increase production in the short term

e: Nominal exchange rate (CDN/US)

Exports price equation can be written as:

$$px = \beta_0 + \beta_1 e + \beta_2 cdp + \beta_3 usp + \beta_4 us\_ipi + \beta_5 cap + \beta_6 cdi + u \qquad (9)$$

Equation 9 is derived using equation (8) from section 3, along with this model and by adding Canadian interest rate (cdi)[1] to capture the interaction between home monetary policy and exchange rate movements: For example, after Cdn dollar appreciation, Bank of Canada could lower the overnight interest rate (and hence short term interest rate) to

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[1] Monthly average of overnight interest rate

support Canadian aggregate demand. This intervention will increase the interest rate differential with the US and hence leads to the depreciation of the Cdn dollar.

In order to estimate equation (9), we adopt Vector Autoregression (VAR) technique to investigate the pass-through of exchange rate fluctuations to exports price $(1 - \beta_1)$, or equivalently the PTM exercised by exporting firms in the US market (β_1). VAR allows us to trace interdependencies between variables hence avoid simultaneity bias resulting from using single OLS regression.

We have 7 variables and 7 industries to be analyzed namely iron and steel products, paper and paperboard, crude oil and natural gas, petroleum and coal manufacturing, plastic and rubber, wood and aluminum.

Preliminary tests

1-Unit root test

We test the stationarity of time series using the Augmented Dickey-Fuller (ADF) test. We use models with an intercept only and with intercept and trend. Lag length for the unit root test is selected by looking at the Akaike Information Criteria, (AIC) and the Schwartz Information Criteria (SIC) .Results are displayed in table(4). All series are stationary in first difference, in other words all series are integrated of first order I (1)

2-Cointegration test

Given that all variables are I (1), we test if a stationary long term relation between the dependent variable and the regressors exists. We carry out the two steps Engle and Granger cointegration test.

Step one: We estimate cointegration relation between exports price and explanatory variables using OLS. We estimate two regressions. Regression 1: we regress our dependent variable on our 6 regressors. Regression 2, we add a linear trend to the regressors.

Step two: We carry out the Augmented Dickey Fuller (ADF) test associated with the residuals

The null hypothesis is the existence of a unit root. If rejected, a unit root doesn't exist hence, a cointegration relation exists. Results are displayed in table (5). Cointegration relation is non existent for crude oil and natural gas, petroleum coal manufacturing, plastic and rubber and wood. However, cointegration relation exists in iron, paper and paperboard and aluminum. In cases where the cointegration relation is absent, a spurious relationship exists between our dependent variable and the regressors. We hence use our variables in first difference. When cointegration relation exists, although OLS estimator is super consistent, OLS standard errors of the coefficients are unreliable (β doesn't have asymptotic normal distribution).Cointegration relation could suffer from endogeneity bias. Therefore, we re-estimate the cointegration relation in step one using Dynamic Ordinary Least Squares (DOLS). In DOLS, we add leads and lags of the first difference of the regressors and hence correcting for all possible endogeneity of the regressors.

Cointegration relation will be estimated as follows:

$$y_t = \alpha_0 + \alpha_1 x_t + \sum_{j=-p}^{p} \phi_j \Delta x_{t-j} + \alpha_2 z_t + \sum_{j=-p}^{p} \delta_j \Delta z_{t-j} + ... + e_t \qquad (10)$$

We test for residuals autocorrelation using Breusch-Godfrey test for autocorrelation. We reject the null hypothesis of no serial correlation. Hence, we conduct DOLS using Newey-West robust standard deviation. Results displayed in table (6) show α_i; the DOLS estimators.

We should then proceed using the Error Correction Model (ECM). In This model, we add the lag of the cointegration relation residual $\hat{e}_{t-1} \sim I(0)$ estimated in equation (10) to our model to get the Error Correction Model as follows:

$$\underbrace{\Delta y_t}_{I(0)} = \beta_0 + \beta_1 \underbrace{\Delta y_{t-1}}_{I(0)} + \beta_2 \underbrace{\Delta x_{t-1}}_{I(0)} + \beta_3 \underbrace{\Delta z_{t-1}}_{I(0)} + ... + \xi \underbrace{\hat{e}_{t-1}}_{I(0)} + u_t \qquad (11)$$

In this study however, we will limit ourselves to the VAR in first difference and this is for the following reasons: 1- Engle and Granger test doesn't provide all cointegration relations that could exist. Johansen cointegration test is usually a better

alternative as it identifies all stationary cointegration relations. However, when we attempted to use ECM our results suffered from over-parameterization and efficiency loss (insignificant coefficients). Moreover, as the independent variables' order is important, we fail to choose the right cointegration relations. 2-We are limited by the small sample period used and hence we focus only on a short term dynamic analysis. 3- Using only one technique; the VAR in first difference enables us to have a homogenous analysis for all industries.

VAR and Impulse Reaction Function estimation

We will estimate an unrestricted VAR in first differences and study the Impulse Response Functions generated. We select the lag length for the VAR (p) that minimizes Akaike Information Criterion (AIC). We also carry out Granger causality Wald tests for the objective function of exports price in order to test individual and global significance of explanatory variables and to identify exogenous variables in the VAR. Non significant explanatory variables in the objective function were omitted. Tests results are displayed in table (7).

The advantage of VAR is that it can be used to determine the response of economic variables to a fundamental economic shock, a procedure called Impulse Response Function (IRF). We will estimate the Cumulative Impulse Response Function CIRF. Based on Marques (2004), the Cumulative Impulse Response Function (CIRF) traces the response's persistence and is simply given by $\dfrac{1}{1-\rho}$ where ρ is the "sum of the autoregressive coefficients.

The reduced-form VAR(p) can be written as follow

$$y_t = c + A(L)y_{t-1} + u_t \, ;$$

Where $y_t = \begin{bmatrix} \Delta px & \Delta e & \Delta pcd & \Delta pus & \Delta usipi & \Delta cap & \Delta cdi \end{bmatrix}'$

c is a vector of deterministic terms ; *A* is a matrix polynomial of degree *p* in the lag operator *L;* and u_t is the (7x1) vector of reduced-form residuals with variance-covariance matrix Ω.

To recover the structural shocks, we use a Cholesky decomposition of the matrix Ω to generate structural disturbances (ε_t). The relationship between the reduced-form VAR residuals and the structural disturbances can be written as follows: (see Ito, Sasaki and Sato (2005))

$$
\begin{pmatrix} u_t^e \\ u_t^{cdp} \\ u_t^{usp} \\ u_t^{usipi} \\ u_t^{cap} \\ u_t^{cdi} \\ u_t^{px} \end{pmatrix} = \begin{pmatrix} S_{11} & 0 & 0 & 0 & 0 & 0 & 0 \\ S_{21} & S_{22} & 0 & 0 & 0 & 0 & 0 \\ S_{31} & S_{32} & S_{33} & 0 & 0 & 0 & 0 \\ S_{41} & S_{42} & S_{43} & S_{44} & 0 & 0 & 0 \\ S_{51} & S_{52} & S_{53} & S_{54} & S_{55} & 0 & 0 \\ S_{61} & S_{62} & S_{63} & S_{64} & S_{65} & S_{66} & 0 \\ S_{71} & S_{72} & S_{73} & S_{74} & S_{75} & S_{76} & S_{77} \end{pmatrix} \begin{pmatrix} \varepsilon_t^e \\ \varepsilon_t^{cdp} \\ \varepsilon_t^{usp} \\ \varepsilon_t^{usipi} \\ \varepsilon_t^{cap} \\ \varepsilon_t^{cdi} \\ \varepsilon_t^{px} \end{pmatrix}
$$

The resulting lower-triangular matrix S implies that some structural shocks have contemporaneous effect on some endogenous variables given the ordering of other endogenous variables. Therefore, the results of the VAR can be sensitive to the choice of ordering of the variables. We have 7 variables so there are 7! =5040 possible orderings. This represents a weakness of the VAR technique. Another weakness of the VAR is that results are very sensitive to lags order.

Economic theory does not provide sufficiently and unambiguous guidance for the ordering of endogenous variables. In this paper, we will attempt to use two ordering. The first one is based on Faruqee (2004) where exchange rate is placed as the first variable. The economic justification is that exchange rate movements—especially at higher volatility—are essentially driven by asset market rather than goods market disturbances. Hence its short-run fluctuations have little to do with macroeconomic variables

considered here. Interest rate is however placed at the end reflecting Bank of Canada reactive response to exchange rate fluctuations.

Model 1: e→ CDP→PUS→ USIPI→CAP→ CDI→PX

The other ordering is derived from Osbat and Wagner (2006) where the nominal exchange rate is placed after the US Industrial Production Index, foreign and domestic producer price indices to allow the exchange rate to adjust to foreign demand and price differentials.

Model2: USIPI → PUS → CDP → e →CAP→ CDI→PX

In our analysis, we estimate four CIRFs: The first one estimates the reaction of cost of production to a disturbance in exchange rate. According to Kardasz and Stollery (2005),

"Changes in the exchange rate have direct and indirect effects on the prices of domestically produced goods and imports in the domestic market. The direct effects originate with the impact of the exchange rate on the marginal cost of imports; the indirect effects, with its impact on the price of materials used by domestic producers and hence on their marginal costs".

Secondly, we estimate the response of exports price to cost of production and exchange rate shocks. Hence, we will trace the direct effect of exchange rate disturbance on exports price and the indirect effect through cost of production. Finally, we estimate exports price reaction to a shock in the US demand.

Empirical results

1-Iron ore and scrap

Graph (5-a) and table (8-1) show that following a disturbance causing the exchange rate to appreciate ($\Delta e < 0$), pass through to lower cost of production ($\Delta dCD\_iron < 0$) is incomplete all across the board except for period 4 where pass through is almost null.

Pass through to cost of production reaches its peak after 7 periods (0.66) then returns to its first period level (0.47). This is coherent with previous empirical findings in industrialized countries that ERPT to imports price is incomplete and hence to cost of production which includes imported materials. Meanwhile, a shock in cost of production is partially reflected into exports price and the reaction to the shock largely decreases after 3 periods (graph (5-b), table (8-2)

Graph (5-c), table (8-3) show that a shock in exchange rate is completely reflected in iron exports price labeled in Cdn dollar in the first quarter. This means that a negative shock on exchange rate (an appreciation) will be accompanied by a proportional decrease in iron export price labeled in Cdn dollar and thus, US dollar export price will remain unchanged. Therefore there is no ERPT[1]. After a quarter, exports price in Canadian dollar will be less and less responsive to exchange rate disturbance (0.3 after 8 periods); reflecting tendency towards complete pass through to US dollar exports price within time. DOLS coefficient from cointegration relation is 0.65 but statistically insignificant (table (6)) which confirms the existence of complete ERPT to US dollar exports price. Graph (5-d) displays how US demand shock for Canadian products will induce a significant positive pressure on iron export price. This is in accordance with the economic theory. Model 2 estimation gives the same results, (see graph (5) model 2)

2- Paper and paperboard:

Graph (8-a) and table (9-1) show that a shock causing exchange rate to decrease by 1 percent will be partially translated into lower cost of production. Pass through to cost of production reaches a peak of 0.8 after 5 periods then declines through time. Graph (8-b) and table (9-2) show that pass-through of cost of production shock into paper and paperboard exports price is almost complete for the first 6 periods (1.00 after 5 periods). It gradually declines afterwards through time. In graph (8-c) Canadian dollar exports price partially responds to an exchange rate disturbance. This response reaches 0.57 after 4 periods then declines through time and eventually becomes insignificant. In other words, after an exchange rate shock exporting firms possessing some market power

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[1] Remember that ERPT is defined according to US dollar exports price: if Cdn $ exports price is completely responsive to exchange rate shock , US $ exports price remains constant; there is no ERPT

adjust exports price to prevent an increase in the US exports price. Hence, ERPT to US dollar export price is incomplete. Through time, ERPT to US dollar exports price tends to be complete. DOLS coefficient in the cointegration relation is 0.008 (($(1-\beta)$) =1) and statistically insignificant reflecting a complete ERPT. Unexpectedly, exports price responds negatively to a positive US demand shock. However, this response is weak. Model 2 leads to same results. See graph 8 model 2.

3-Crude Petroleum and natural gas

IRF graph (11-a) and table (10-1) show that a one percent shock in exchange rate will be partially passed through to lower cost of production. Pass through will thereafter be complete after six periods (1.19) then slightly declines reaching 0.9 after 7 periods. Export prices will mostly move one-to–one with cost of production shocks and sometimes overshoots the shock. Canadian dollar export price will proportionally respond to an exchange rate shock after two periods (0.96), as we can observe in graph (11-c). This means that exporting firms will entirely absorb the Cdn dollar appreciation into lower profits and thus maintaining the US dollar price constant. However, this quick response drops one period later, and continues its drop (0.1 after 8 periods) and sometimes has a negative sign. This means that even though exporting firms try to maintain their US dollar right after the shock, this control doesn't persist. Therefore we can conclude that ERPT to US dollar price exports price tends to be complete in the long term. Unexpectedly, export prices reaction to a shock in US demand has a negative sign. This means that with a negative shock in the US demand, crude petroleum and natural gas will continue to rise. However, the negative effect will decrease in time and eventually will turn to a positive effect as expected by the economic theory. Model 2 leads to same results (see graph 11 model 2).

4-Petroleum and coal manufacturing

Graph (14-a) and table (11-1) show how cost of production responds proportionally to a shock in exchange rate after two periods (1.04). This is against current literature arguing that pass through is incomplete especially in the very short run. However, pass through will decline thereafter tending to zero confirming that pass through will eventually be

null. Unexpectedly, exports price response to cost of production shock has the wrong sign. Although graph (12) shows how export price and cost of production move altogether, CIRF shows the opposite. Pass through to Canadian dollar export prices follows the same pattern as the pass through to cost of production. However, the former is of larger effect. Cdn dollar export price will move more than one to one with an exchange rate shock in the first quarter (1.2 after 4 periods). This is explained by exporting firms keenness to lower their margin of profits in the short run to mitigate the appreciation of the Cdn dollar hence prevent losing the US market. ERPT to US dollar export price is null in the very short term. Graph (14-c) and table (11-3) show that Cdn dollar response to exchange rate shock will drop afterwards reflecting an incomplete ERPT to US dollar oil and coal exports price.

The effect of a shock in US economy on Canadian dollar export price is very significant reflecting US market's important demand to this industry. It is worthwhile mentioning that Exchange Rate Pass Through is similar in both crude petroleum and natural gas and petrol and coal manufacturing industries especially in the very short term. Pass through to the latter industry is however higher in the longer term. Model 2 gives the same results.

5-Plastic and rubber

Graph (17-a) and table (12-1) show that a one percent decrease in exchange rate will not be translated to any decrease in cost of production. This is clear from the CIRF where the reaction is almost zero all across the board. We can conclude that there is no ERPT to Canadian imports price and hence no ERPT to lower cost of production. Exports price however, overreacts to a shock in cost of production. Exports price reaction to exchange rate shock has non expected sign. Graph (17-c) and table (12-3) show that a one percentage appreciation will be accompanied by less than one percent increase in exports price labeled in Canadian dollar. This increment will decrease by time (-0.51 after 8 periods). That means that US dollar exports price will increase more than one to one with Canadian dollar appreciation. Or in other words, exports firms will continue to raise their markup over cost of production even with a negative shock in exchange rate. This could be explained by a high US demand and/or by a low US demand elasticity to Canadian

plastic &rubber price. Graph (17-d) and table (12-4) show that a positive shock in US demand will push up exports price, which is consistent with the economic theory. Model 2 leads to the same results.

6-Wood

Graph (20-a) and table (13-1) show that a one percent decrease in exchange rate will be partially passed through to lower cost of production in the short term (0.44 after 3 periods). This trend will reverse afterwards. Cost of production increases even with Canadian dollar appreciation. When we study the reaction of cost of production to US price, we found that the CIRF is almost zero (see table (13-5)) which means that cost of production is non reactive to a shock to US price. Exports price will partially react to cost of production shock. Graph (20-c) and table (13-3) show that exports price will partially react to exchange rate shock up until the third period; i.e. there is partial ERPT. Afterwards, Cdn dollar exports price will not react to the shock letting US dollar exports price increase proportionally to the exchange rate appreciation (β=0.02 and 1- β= 0.98 after 5 periods). In the longer term, exports price increases more than proportionally than the initial shock, reflecting the increasing of cost of production impact on exports price. Finally, US demand shock will increase Cdn dollar exports price in the very short term and then this effect gets reversed.

7-Aluminum

Graph (23-a) and table (14-1) show cost of production weak reaction to exchange rate disturbance it reaches its lowest level -0.00 after 4 periods. Unexpectedly, exports price reaction to cost of production shock will have an opposite sign. Graph (23-c) and table (14-3) show how Cdn dollar exports price partially decreases with a negative shock in Cdn exchange rate; β= 0.33 and 1- β =0.67. Pass through will decline within time reflecting a tendency towards complete ERPT in the longer run where β=0.19 and (1- β) =0.81. DOLS coefficient in the cointegration relation is 0.17((1- β) = 0.83) confirming tendency towards complete ERPT. Finally, US demand shock has a positive and increasing effect on Cdn exports price.

Section 6

Conclusion

The Canadian dollar appreciation since early 2002, had caused concerns about the future of goods exports to the United-States; our first trading partner. Hence, studying the degree of Exchange Rate Pass-Through (ERPT) to the US dollar exports price is a good measure of the degree of loss of competitiveness of the Canadian goods in the US market.

In this paper we studied the degree of ERPT to the top seven crude and fabricated materials exported to the United-States. They include iron ore and scrap, paper and paper board, crude petroleum and natural gas, petroleum and coal manufacturing, synthetic rubber and plastic, wood and aluminum. Our study covers the period 2002:1- 2007:3. We used the VAR technique and estimated the Cumulative Response Impulse Function (CIRF) to trace the time path of exports price response to an exchange rate shock. Our model is built on the Pricing To Market (PTM) model and Rockerbie (1992) .

Our main findings are the followings: For the iron scrap and ore industry, ERPT to US dollar exports price is null after four periods following an exchange rate shock. However, in the longer run Cdn dollar exports price are less and less responsive to the exchange rate shock reflecting a higher ERPT to US dollar exports price in the longer run. As for the paper and paper board industry, ERPT is incomplete in the short term (0.57 after four periods). In the longer term, US dollar exports price will move proportionally to the exchange rate shock. Hence, there will be complete ERPT in the longer term. For crude petroleum and natural gas, Cdn dollar exports price will move proportionally to the exchange rate shock right after the shock. Therefore, there will be no ERPT after two periods. However, Canadian dollar response to the shock will decline in time. ERPT will be close to complete in the long run. In the petroleum and coal manufacturing industry, ERPT is null after four periods. In the longer run, US dollar exports price will partially respond to the shock reflecting an incomplete ERPT. Concerning plastic and rubber industry, US dollar exports price will overreact a shock causing the Cdn dollar to appreciate. ERPT will be more than one. This could be explained by a demand curve extremely convex and hence exporting firms will continue

to gain higher profits with Cdn dollar appreciation. In the wood industry, there will be a partial ERPT in the very short term. ERPT will increase by time and eventually becoming more than one. Finally, we found partial ERPT in the short term and tendency towards complete ERPT in the long term for aluminum industry.

Our results are consistent with current literature that found evidence of incomplete and weak ERPT into imports price in the United-States in the sort run. However, Rockerbie (1992) found evidence of high degree of ERPT to exports price. This difference could be due to the difference in the direction of the exchange rate movement in the periods studied: While he covers the period going from 1971:1 to 1990:2 where the Cdn dollar was depreciating, we cover the period going from 2002:1 to 2007:3 where the Cdn dollar is appreciating. ERPT behavior is hence asymmetric in these two cases. A second reason would be that he used aggregated sectors. In each sector, we could find evidence of disparity in the degree of ERPT.

Bibliography

Abali Elif Ege, "Exchange Rate Pass-Through into the export and import prices of Turkey", a thesis submitted to the graduate school of social sciences of Middle East technical university, 2006

An Lian, "Exchange Rate Pass-Through:Evidence Based on Vector Autoregression with Sign Restrictions", Munich Personal RePEc Archive, Paper No. 527, 2006, 01-06

Campa Jose´ Manuel and S. Goldberg Linda, "Exchange Rate pass-Through into import price", Review of Economics and Statistics, Vol. 87, No. 4, 2005, 679-690

Dornbusch Rudiger, "Exchange rate and prices", Massachusetts Institute of Technology (MIT), NBER Working Paper No.W1769, 1987

Department of Foreign Affairs and International Trade Canada, "Canada's State of Trade, Trade and Investment Update – 2007", Catalogue No. IT1-3/2007

Faruqee Hamid "Exchange Rate Pass-Through in the Euro Area", IMF Staff Papers
Vol. 53, No. 1, 2006

Faruqee Hamid, "Exchange Rate Pass-Through in the Euro Area: The Role of Asymmetric Pricing Behavior", IMF Working Paper, No.04/14, 2004

Ferreira Afonso and Sansó Andreu, "Exchange Rate Pass-Through: the case of Brazilian exports of manufactures", XIIo. World Congress of the International Economic Association, 1999

Hooper P. and Mann, C. L., "Exchange Rate Pass-Through in the 1980s: The Case of U.S. Imports of Manufactures", Brookings Papers on Economic Activity, 1, 297-337, 1989

Ito Takatoshi, N. Sasaki Yuri and Sato Kiyotaka, "Pass-Through of Exchange Rate Changes and Macroeconomic Shocks to Domestic Inflation in East Asian Countries", RIETI Discussion Paper Series 05-E-020, 2005

Kardasz W. Stanley and Stollery Kenneth R., "Exchange rate pass-through in Canadian manufacturing: its direct and indirect components", Applied Economics, 2005, 37, 1763–1776

Khundrakpam Jeevan Kumar, "Economic reforms and exchange rate pass-through to domestic prices in India", Bank for International Settlements, BIS Working Papers No 225, 2007

Krugman Paul, "pricing to market when the exchange rate changes", National Bureau of Economic Research, Working Paper No.1926, 1986

Marques Carlos Robalo, "Inflation persistence: facts or artifacts?", European Central Bank, working paper series No. 371, 2004

Osbat Chiara and WagnerMartin, "Sectoral Exchange Rate Pass-Through in the Euro Area", European Central Bank and Institute for Advanced Studies Vienna, 2006

Rockerbie Duane W., "exchange rate, pass through, and Canadian export competitiveness: an analysis using vector autoregressions", Applied Economics, 1992, 24,627-634

Vigfusson Robert J., Sheets Nathan, and Gagnon Joseph, "Exchange Rate Pass-Through to Export Prices: Assessing Some Cross-Country Evidence", Board of Governors of the Federal Reserve System, International Finance Discussion Papers No.902, 2007

Yang Jiawen, "Is exchange rate pass-through symmetric? Evidence from US imports", Applied Economics, 2007, 39, 169–178

Appendix A

Tables

Table1: Monthly Pass-Through elasticities in trade prices: international comparisons, Faruqee (2006)

	$t = 1$	$t = 6$	$t = 12$	$t = 18$
		Import Prices		
Euro area	0.03	0.42	0.81	1.17
United States	0.06	0.15	0.18	0.30
Japan	0.61	0.56	0.57	0.57
United Kingdom	0.28	0.58	0.57	0.60
Canada	0.68	0.54	0.62	0.68
		Export Prices		
Euro area	0.02	0.18	0.31	0.45
United States	0.00	0.00	0.06	0.12
Japan	0.62	0.50	0.48	0.47
United Kingdom	0.16	0.47	0.46	0.50
Canada	0.35	0.19	0.35	0.44

Source: IMF staff estimates.

Notes: Based on impulse-response functions from six-variable VAR estimated from 1990 through 2002. For euro area, import and export prices are based on unit values in manufacturing trade. For others, import and export prices are based on unit values in total trade.

Table 2: The Standard International Trade Classification (SITC), Revision 3 and the North American Industry Classification System (NAICS) conciliation

Canadian Exports Prices (STIC)	Canada IPP (NAICS)	US IPP (NAICS)	Capacity Utilization rate (NAICS)
Sec 3.3 Iron ore concentrate and scrap	Series 330-0006 iron ore and iron ore scrap	21221 Iron ore mining	mining
Sec 3.8, sec 3.9 crude petroleum &natural gas extraction (average)	Series 330 0006 crude mineral oil and natural gas	211111 Crude petroleum and natural gas extraction	211 oil and gas extraction
Sec 4.5 other paper and paperboard	32213 paperboard mills	32213 Paperboard mills	322 paper manufacturing (mfg)
Sec 4.11 petroleum & coal products	324 Petroleum &coal mfg	324 Petroleum &coal mfg	324 Petroleum &coal mfg
Sec 4.9 synthetic rubber and plastics	326 plastic and rubber mfg	326 plastic and rubber mfg	326 plastic and rubber products mfg
Sec 4.1 lumber	321 wood product mfg	WPU08 wood product and lumber[1]	321wood product mfg
Sec 4.15 Aluminum, including alloys	3313 Alumina and aluminum production	Primary aluminum production 331312,Aluminum sheet, plate and foil manufacturing 331315,Aluminum extruded product manufacturing 331316 (average)[2]	331primary metal mfg

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[1] This series is the PPI commodity data instead of PPI industry data (no 321). It is chosen instead of series 321 because this latter starts in 2004.

[2] Alumina & aluminum production (series no 3313) starts in 2005. We take an average of available subgroups of aluminum products series starting in 2002.

Table 3: The North American Industry Classification System (NAICS) and Industry group conciliation: US IPI

Industry	Industry Group	NAICS code
iron ore and iron ore scrap	Durable goods materials	21221
Crude petroleum and natural gas extraction	Non Durable goods materials	211111
Petroleum &coal mfg	Non Durable goods materials	324
paperboard mills	Non Durable goods materials	32213
Synthetic rubber and plastic	Durable goods materials	326
lumber	Durable goods materials	3211
Aluminum	Durable goods materials	3313

Table 4: Unit root test results

Δ: first difference
(UR): presence of unit root
(*), (**): rejection of null hypothesis of unit root (5 % and 10 % level of significance respectively)

series	lags		Intercept		Intercept and trend		Δ	Intercept		Intercept and trend	
	AIC	SIC	AIC	SIC	AIC	SIC		AIC	SIC	AIC	SIC
Exrate	5	5	UR	UR	UR	UR		*	*	*	*
USIPI_NDGC	2	1	UR	UR	UR	UR		*	*	*	*
USIPI_NDM	0	0	UR	UR	UR	UR		*	*	*	*
USIPI_DM	7	7	UR	UR	UR	UR		**	**	UR	UR
CD_i	5	1	UR	UR	UR	UR		*	*	*	*
PCD_iron	11	9	UR	UR	UR	UR		**	*	UR	**
PCD_crdpetgas	0	0	UR	UR	UR	UR		*	*	*	*
PCD_paper	2	2	*	*	UR	UR		*	*	*	*
PCD_petcoalmfg	2	2	UR	UR	UR	UR		*	*	*	*
CD_plastic	2	2	UR	UR	UR	UR		*	*	*	*
CD_wood	1	1	UR	UR	UR	UR		*	*	*	*
CD_alum	1	1	UR	UR	UR	UR		*	*	*	*
PUS_petcoalmfg	3	3	UR	UR	UR	UR		*	*	*	*
US_plastic	1	1	UR	UR	UR	UR		*	*	*	*
US_wood	12	12	UR	UR	UR	UR		*	*	*	*
US_alum	12	10	UR	UR	UR	UR		*	*	*	*
PX_paper	1	1	UR	UR	UR	UR		*	*	*	*
PX_aircraft	0	0	UR	UR	UR	UR		*	*	*	*
PX_plastic	0	0	UR	UR	UR	UR		*	*	*	*
PX_wood	2	2	UR	UR	UR	UR		*	*	*	*
PX_alum	0	0	UR	UR	UR	UR		*	*	*	*
CAP_paper	12	3	UR	*	UR	UR		*	UR	*10%	UR
CAP_petcoal_mfg	0	0	UR	UR	UR	UR		*	*	*	*
CAP_plastc	0	0	UR	UR	UR	UR		*	*	*	*
CAP_wood	0	0	UR	UR	UR	UR		*	*	*	*
CAP_alum	0	0	UR	UR	UR	UR		*	*	*	*

Table 5: Engle and Granger cointegration test, step two: Augmented Dickey Fuller test associated with the residuals

Residuals Regression 1	Residuals regression 2	Lags	Test statistic		ADF 5% critical value for 6 independent variables		Cointegration
			const	Const+trend	const	Const+ trend	
uiron		0	-5.187	-5.152	-4.71	-4.74	**I(0)**
	utiron	0	-5.405	-5.355	-4.71	-4.74	**I(0)**
upaper		3	-5.049	- 5.093	-4.71	-4.74	**I(0)**
	utpaper	3	-4.903	-4.917	-4.71	-4.74	**I(0)**
ucrdpetgas		0	-3.936	-3.922	-4.71	-4.74	I(1)
	utcrdpetgas	0	-4.510	-4.464	-4.71	-4.74	I(1)
upetcoalmfg		6	-2.285	-2.880	-4.71	-4.74	I(1)
	utpetcoalmfg	6	-2.373	-3.041	-4.71	-4.74	I(1)
uplastic		12	-2.559	-2.840	-4.71	-4.74	I(1)
	utplastic	12	-2.525	-2.784	-4.71	-4.74	I(1)
uwood		5	-3.191	-3.829	-4.71	-4.74	I(1)
	utwood	5	-3.150	-3.731	-4.71	-4.74	I(1)
ualum		0	-4.813	-4.812	-4.71	-4.74	**I(0)**
	utalum	0	-5.441	-5.400	-4.71	-4.74	**I(0)**

Table 6: Engle and Granger cointegration test, step one: DOLS estimation of the cointegration relation

Independent variable	Log_ PCD	Log_ exrate	Log_ PUS	Log_ CAP	Log_ USIPI	CD_i	constant
lgPX_iron	1.6187 (1.4216)	.6474 (1.6473)	-.1906 (.7221)	-1.8840 (.4678)	1.5587 (3.7186)	-.2808 (.6370)	-.60571 (13.3112)
LgPX_paper	.1335 (.6106)	.0083 (.3000)	.951685 (.5683)	.4550 (.5102)	-1.1312 (.7083)	.1530 (.0553)	2.4713 (2.5012)
LgPX_alum	.6922 (.2640)	.1784 (.9556)	.2095 (.3090)	.2398 (.3063)	-.1453 (1.7676)	.03194 (.0288)	-.0699 (9.008)

* Newey West Standard error in brackets

Table 7: Granger causality test result

-: No exclusion

industry	Selected VAR lags	Granger causality exclusion
Iron	4	-
Petroleum and coal mfg	4	-
Crude petroleum and natural gas	6	US price
Paper and paperboard	6	CAP
Plastic and rubber	4	CAP
wood	4	CAP
aluminum	4	CAP

Appendix B
Graphs

Graph 1: Top-10 merchandise exports to the United States, 2006

FIGURE 4-10A
Top-10 Merchandise Exports to the U.S., 2006

Category	$ billions
Iron and steel products	5.8
Furniture & bedding	7.0
Aluminum	10.7
Paper & paperboard	12.2
Plastic	13.1
Electrical machy & equip.	14.9
Wood	14.9
Machinery	25.8
Motor vehicles and parts	70.5
Mineral fuel and oils	84.2
Other	100.1

$ billions

Source: Canada's state of trade-2007, Department of Foreign Affairs and International Trade Canada

Graph 2: Monthly nominal exchange rate evolution (1998m1-2008m1)
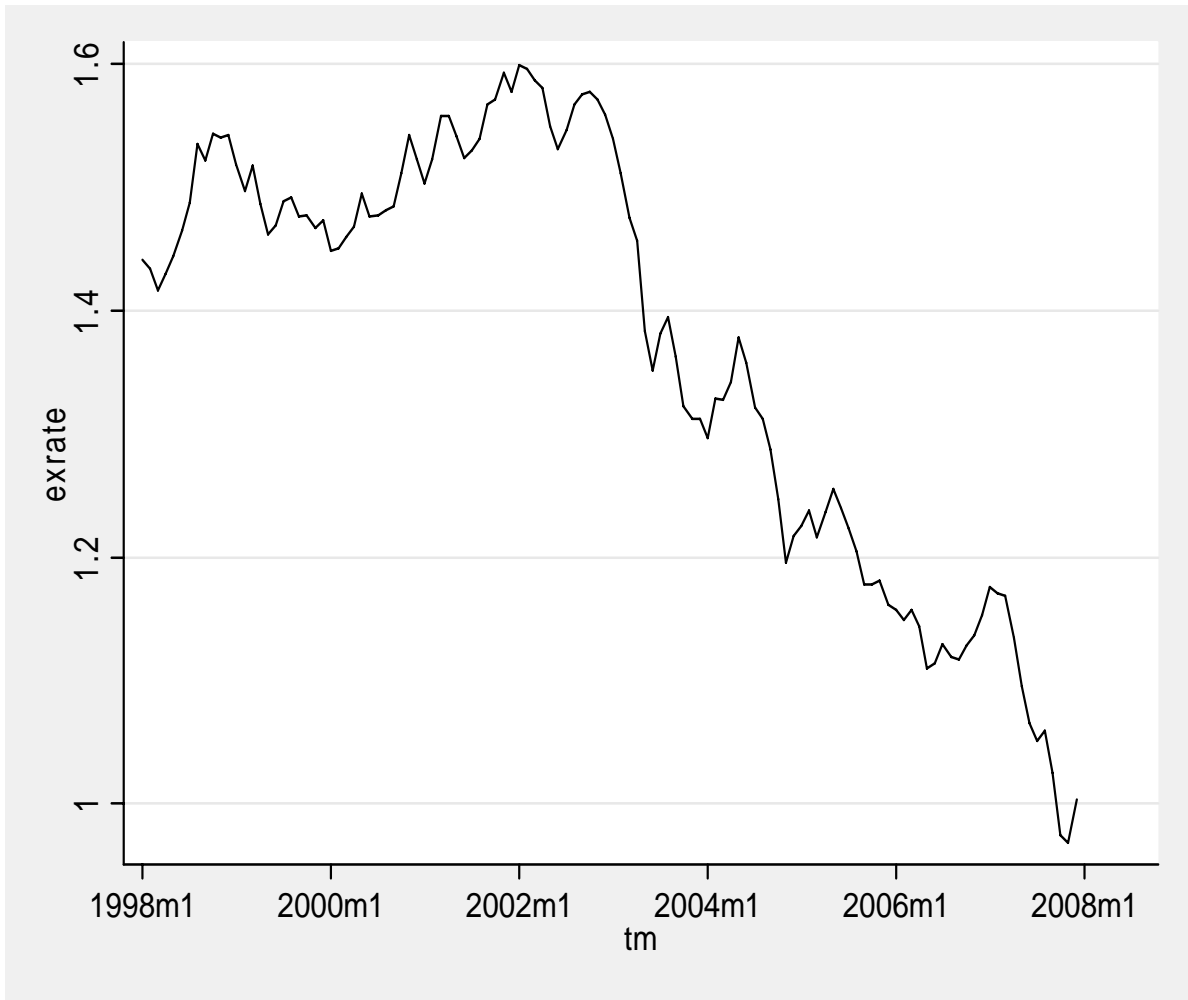
Iron ore and scrap

Graph 3: Evolution of exports price and Cost of production (log)
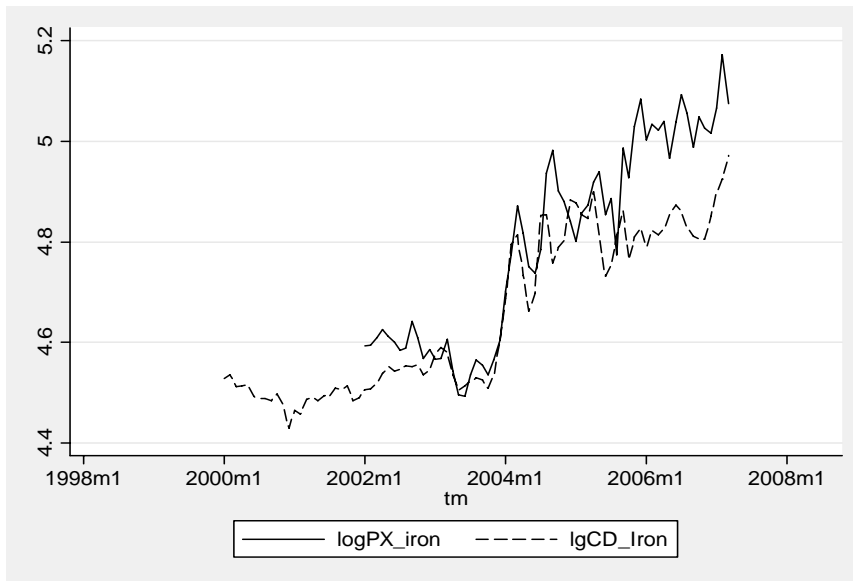
Graph 4: Exchange rate and exports price (variation in %)
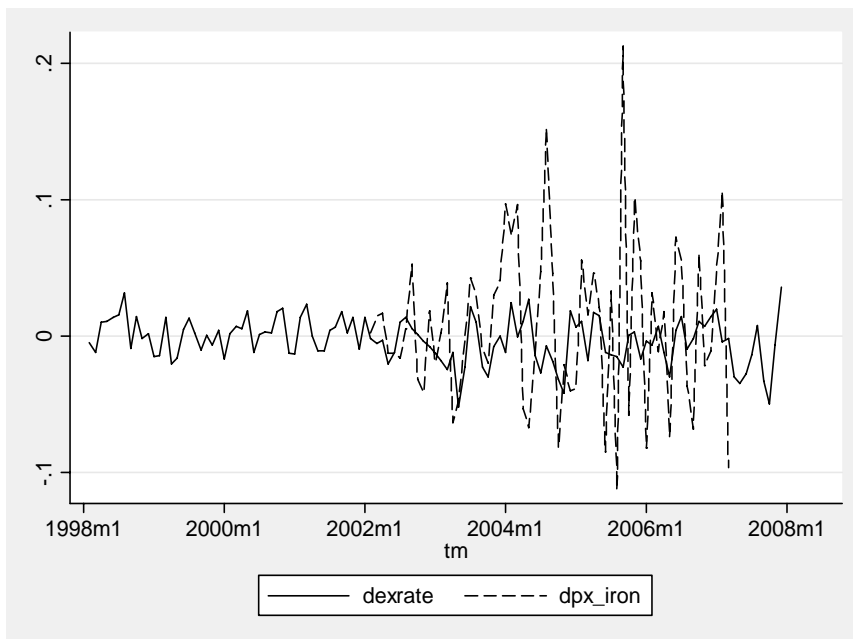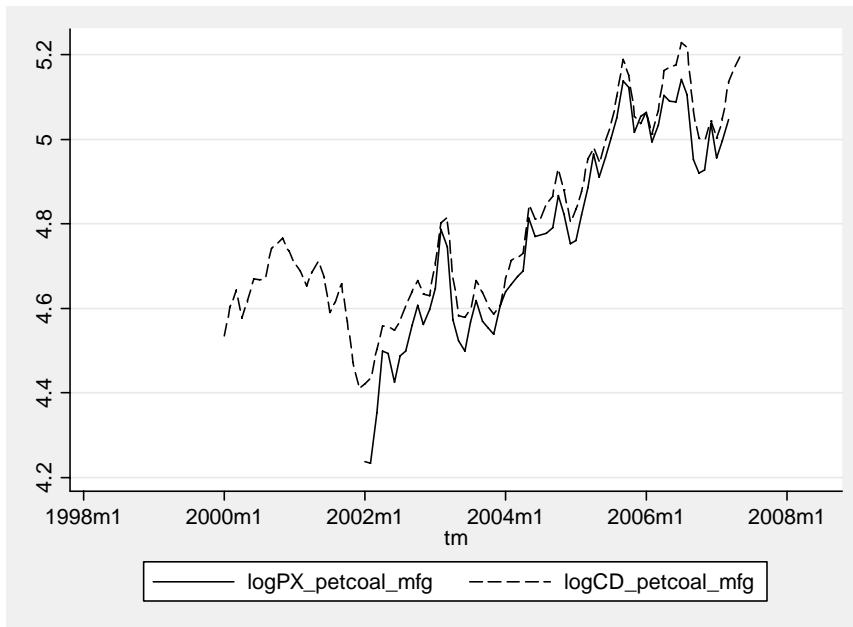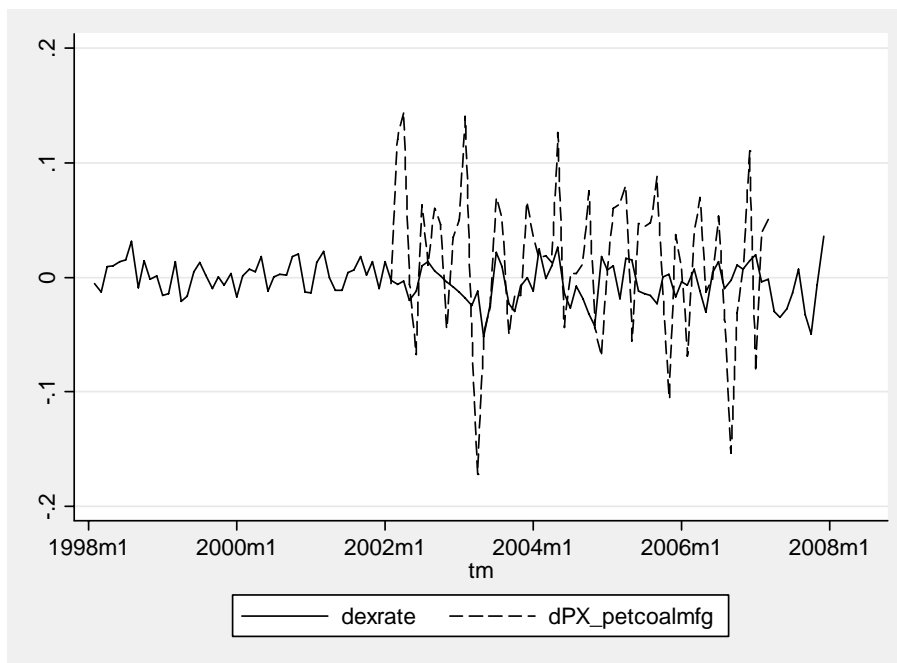
Graph 5: Iron ore and scrap CIRFs

Model 1
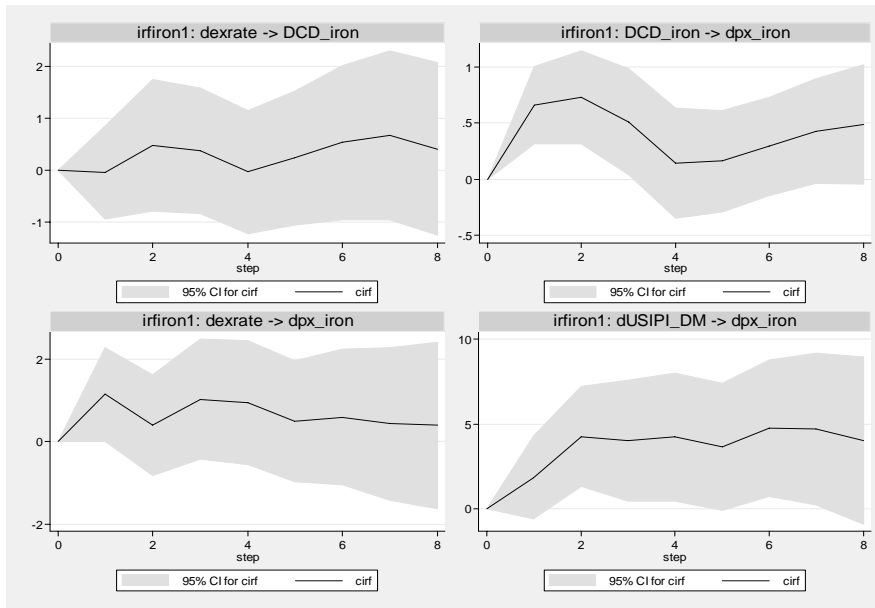
(Up-left) a- Impulse: exchange rate, response: cost of production
(Up-right) b- Impulse: cost of production, response: exports price
(Down left) c- Impulse: exchange rate, response: exports price
(Down right) d- Impulse: US demand, response: exports price

Model 2
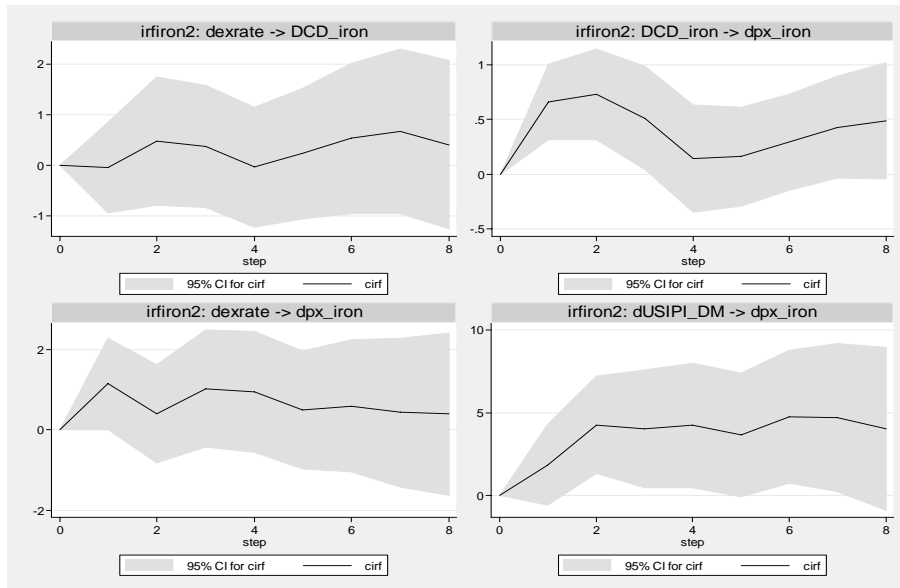
(Up-left) a- Impulse: exchange rate, response: cost of production
(Up-right) b- Impulse: cost of production, response: exports price
(Down left) c- Impulse: exchange rate, response: exports price
(Down right) d- Impulse: US demand, response: exports price

Paper and paperboard

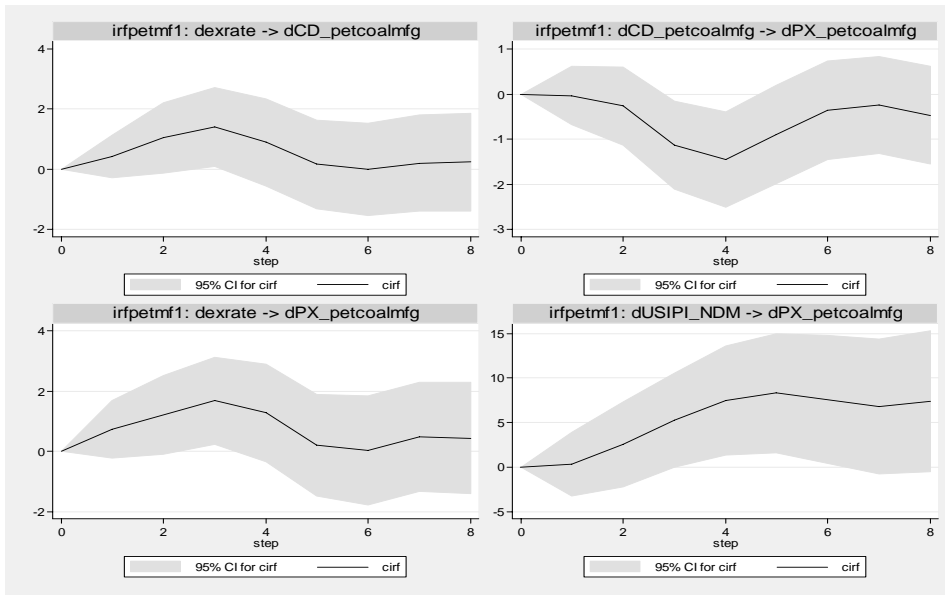**Graph 6:** Evolution of exports price and cost of production (log)
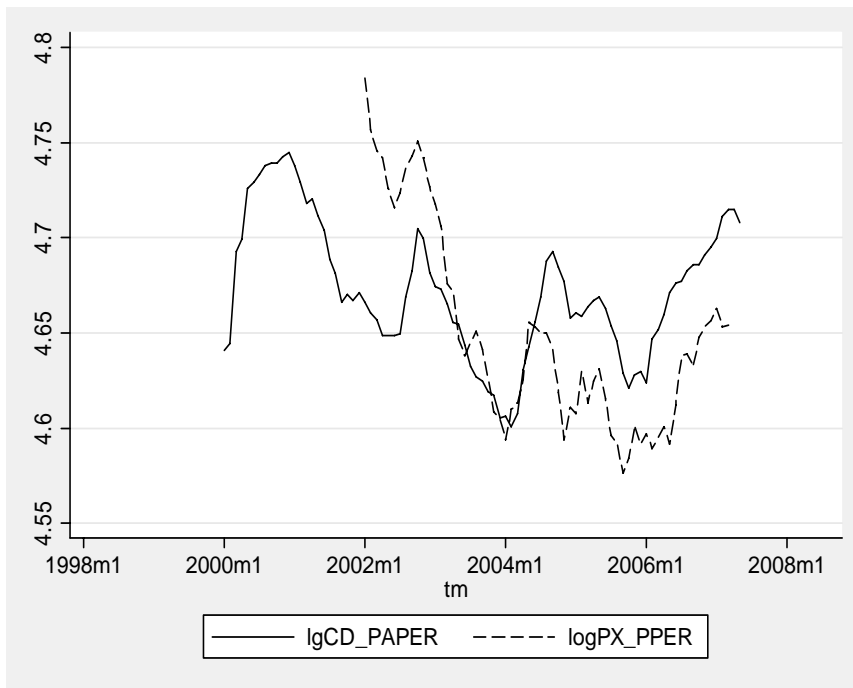
Graph 7: Exchange rate and exports price (variation in %)
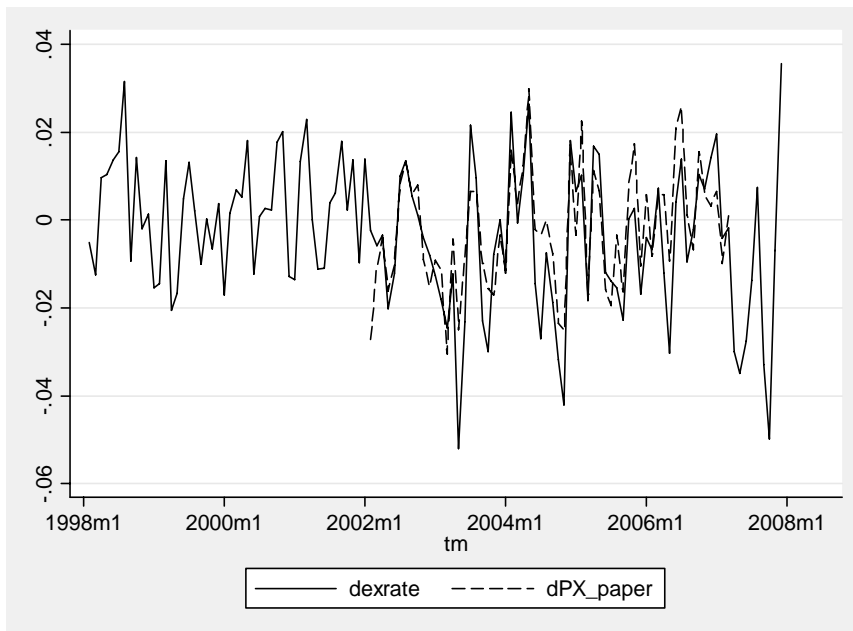
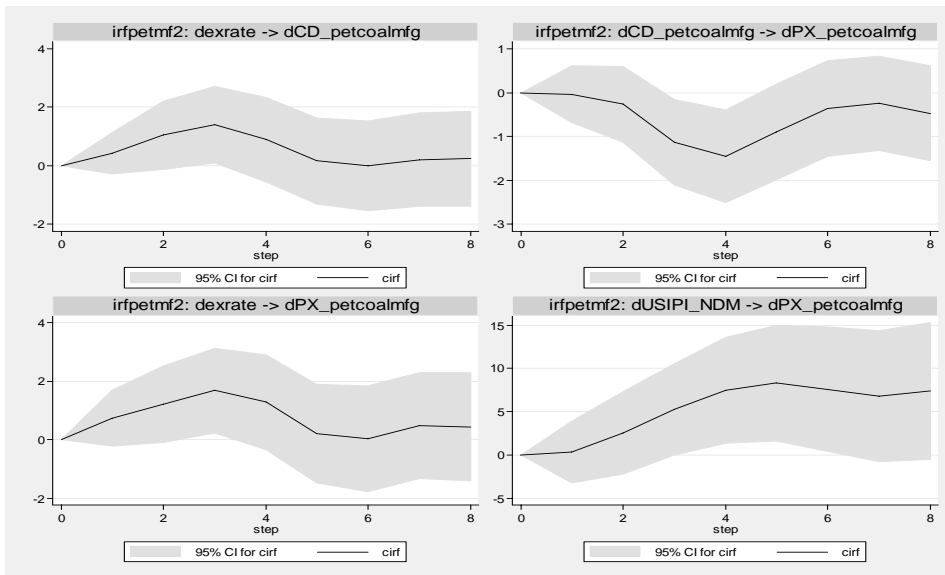**Graph 8**: Paper and paper board CIRFs
Model 1
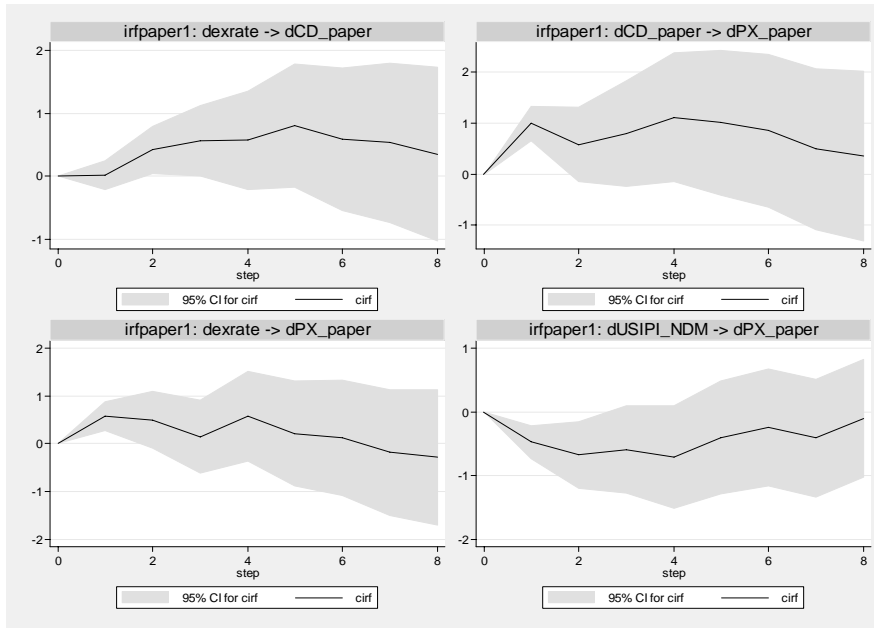
(Up-left) a- Impulse: exchange rate, response: cost of production
(Up-right) b- Impulse: cost of production, response: exports price
(Down left) c- Impulse: exchange rate, response: exports price
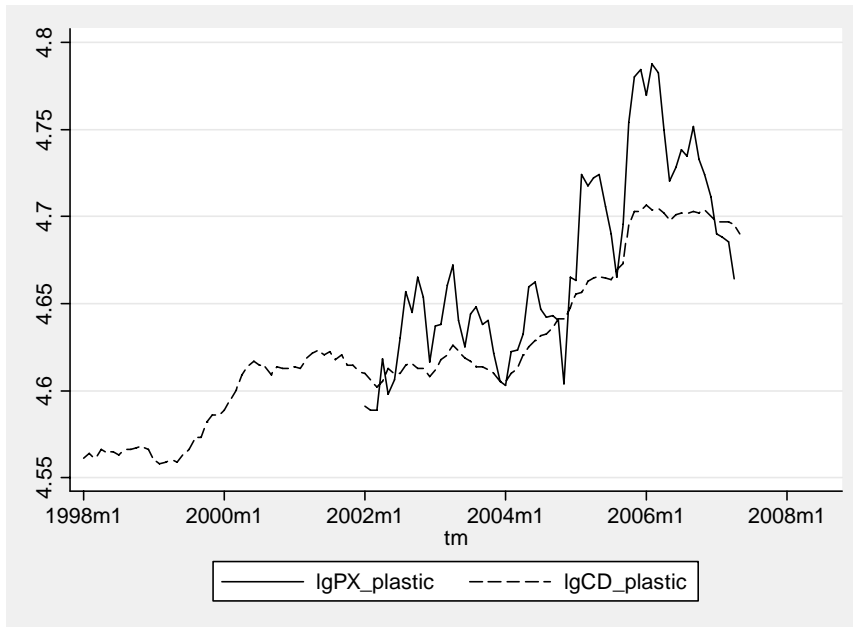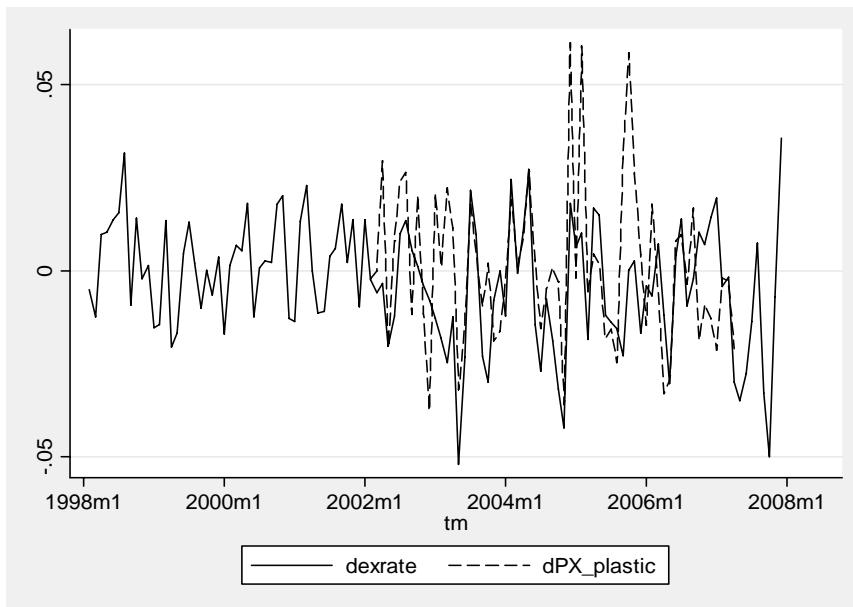(Down right) d- Impulse: US demand, response: exports price

Model 2
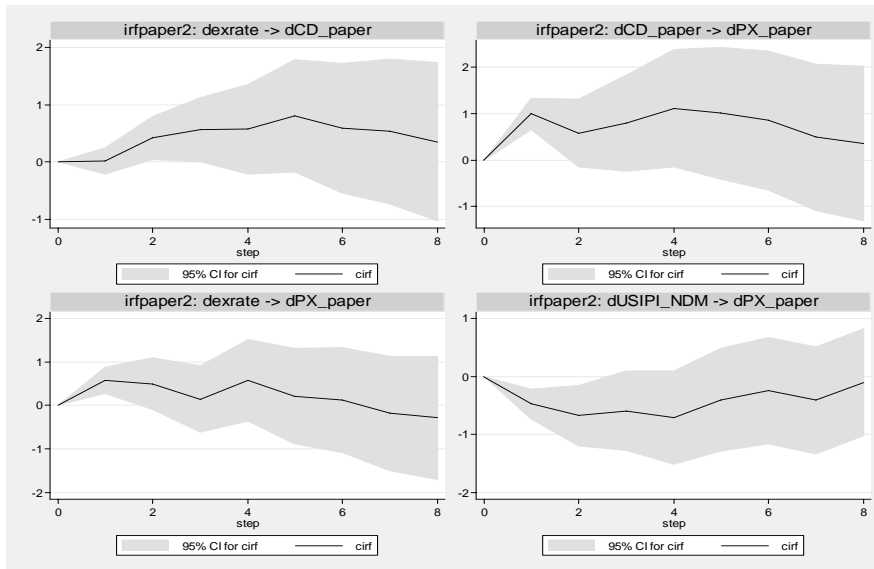
(Up-left) a- Impulse: exchange rate, response: cost of production
(Up-right) b- Impulse: cost of production, response: exports price
(Down left) c- Impulse: exchange rate, response: exports price
(Down right) d- Impulse: US demand, response: exports price

Crude petroleum and natural gas

Graph 9: Evolution of exports price and cost of production (log)
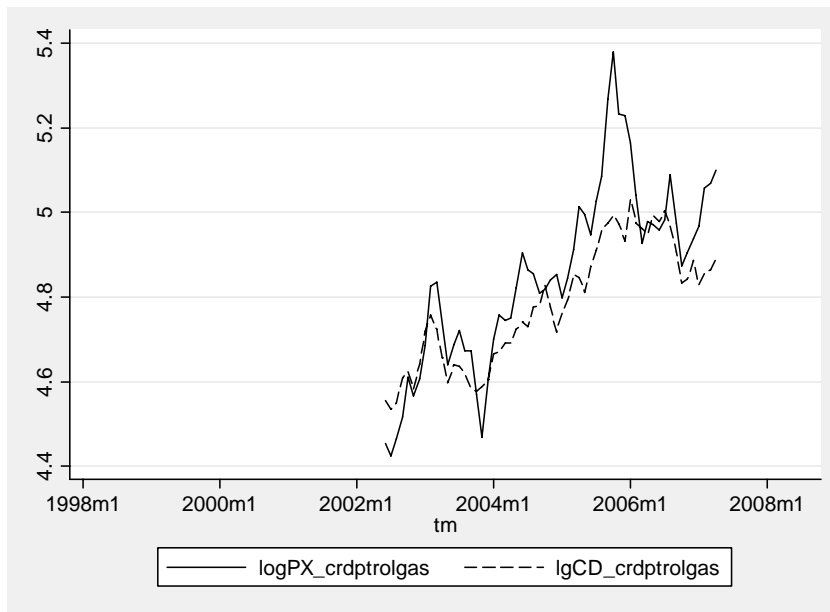
Graph10: Exchange rate and exports price (variation in %)
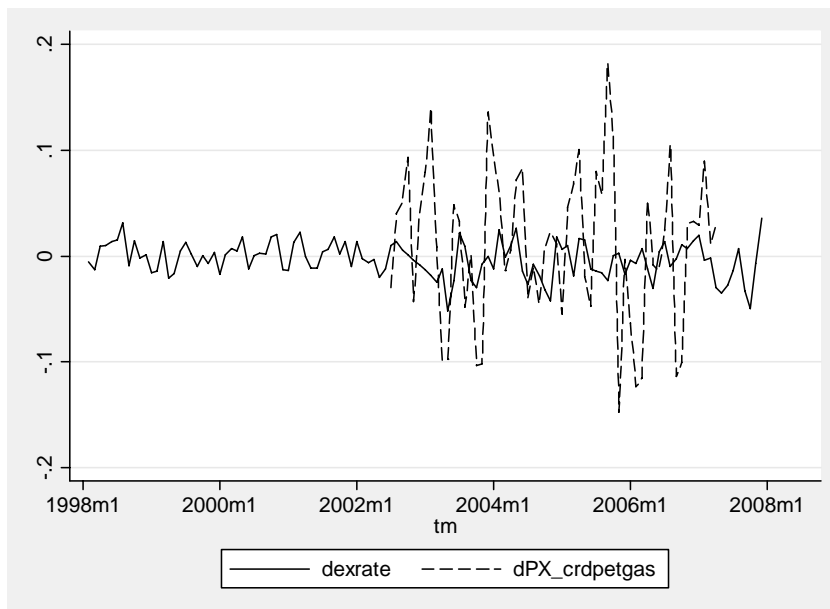
Graph 11: Crude petroleum and natural gas CIRFs
Model 1
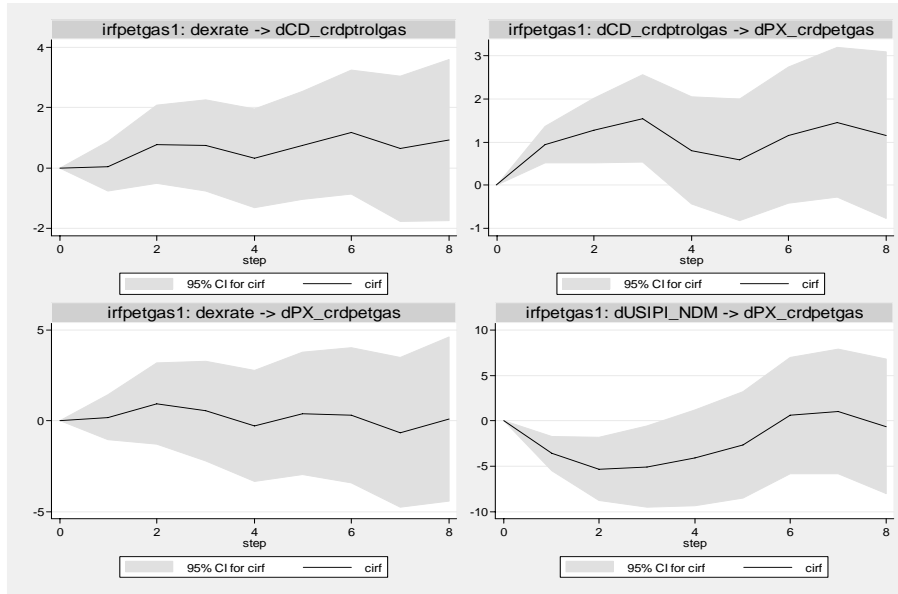
(Up-left) a- Impulse: exchange rate, response: cost of production
(Up-right) b- Impulse: cost of production, response: exports price
(Down left) c- Impulse: exchange rate, response: exports price
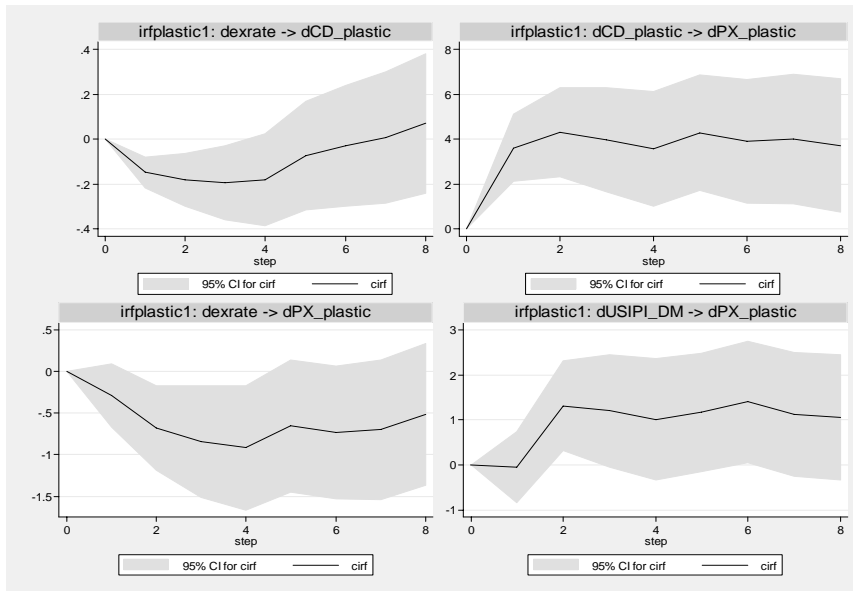(Down right) d- Impulse: US demand, response: exports price

Model 2
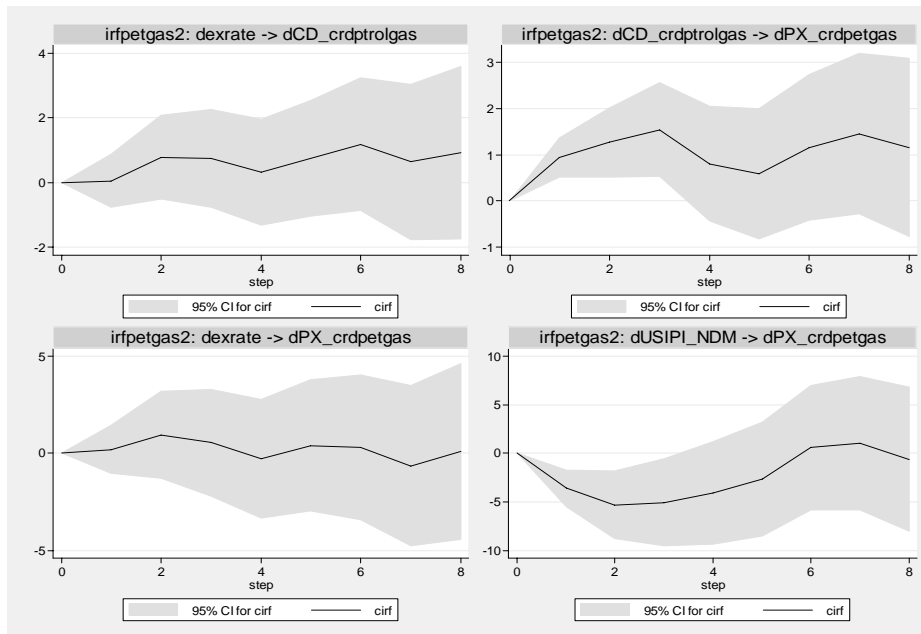
(Up-left) a- Impulse: exchange rate, response: cost of production
(Up-right) b- Impulse: cost of production, response: exports price
(Down left) c- Impulse: exchange rate, response: exports price
(Down right) d- Impulse: US demand, response: exports price

Petroleum and coal manufacturing

Graph 12: Evolution of exports price and cost of production (log)

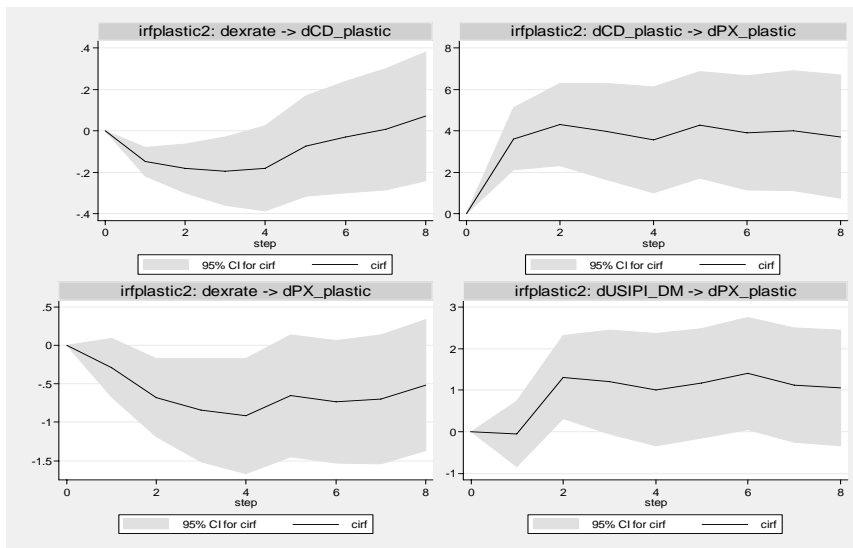**Graph 13:** Exchange rate and exports price (variation in %)

Graph 14: Petroleum and coal manufacturing CIRFs

Model 1

(Up-left) a- Impulse: exchange rate, response: cost of production
(Up-right) b- Impulse: cost of production, response: exports price
(Down left) c- Impulse: exchange rate, response: exports price
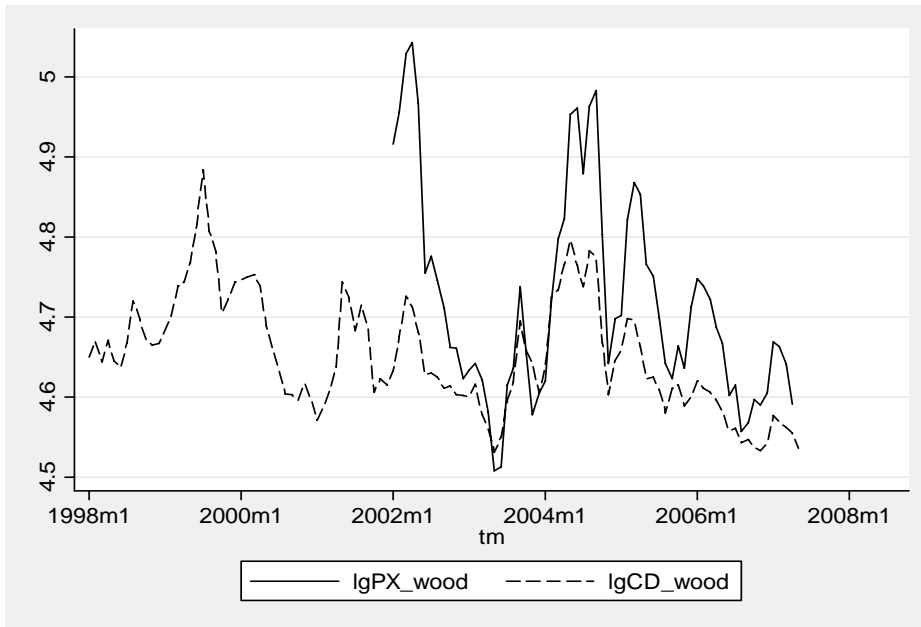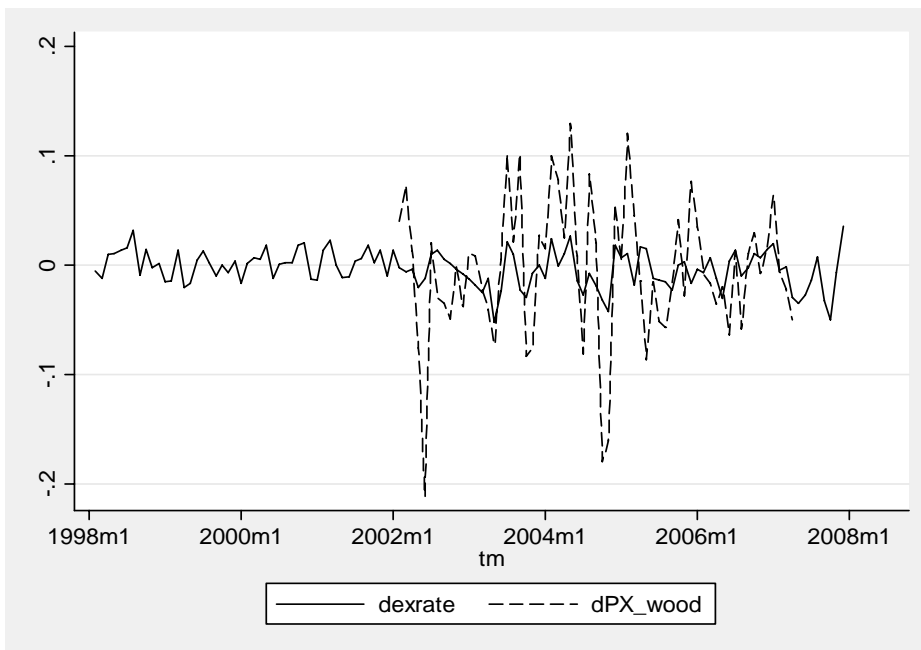(Down right) d- Impulse: US demand, response: exports price

Model 2

(Up-left) a- Impulse: exchange rate, response: cost of production
(Up-right) b- Impulse: cost of production, response: exports price
(Down left) c- Impulse: exchange rate, response: exports price
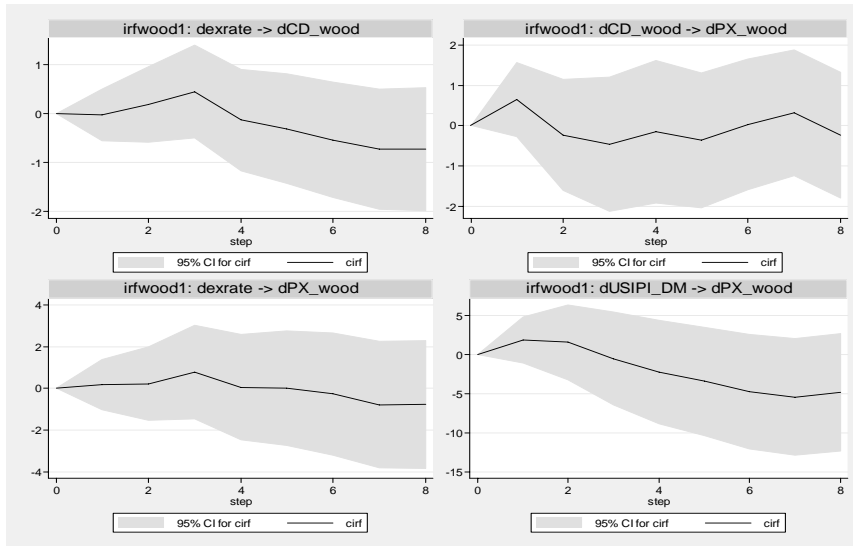(Down right) d- Impulse: US demand, response: exports price

Plastic and rubber

Graph 15: Evolution of exports price and cost of production (log)

Graph16: Exchange rate and exports price (variation in %)

Graph 17: plastic and rubber CIRFs
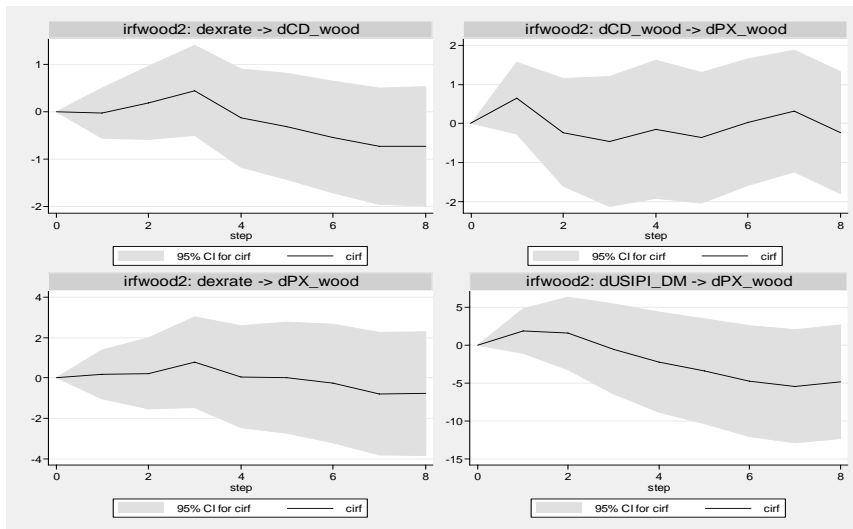**Model 1**

(Up-left) a- Impulse: exchange rate, response: cost of production
(Up-right) b- Impulse: cost of production, response: exports price
(Down left) c- Impulse: exchange rate, response: exports price
(Down right) d- Impulse: US demand, response: exports price

Model 2

(Up-left) a- Impulse: exchange rate, response: cost of production
(Up-right) b- Impulse: cost of production, response: exports price
 (Down left) c- Impulse: exchange rate, response: exports price
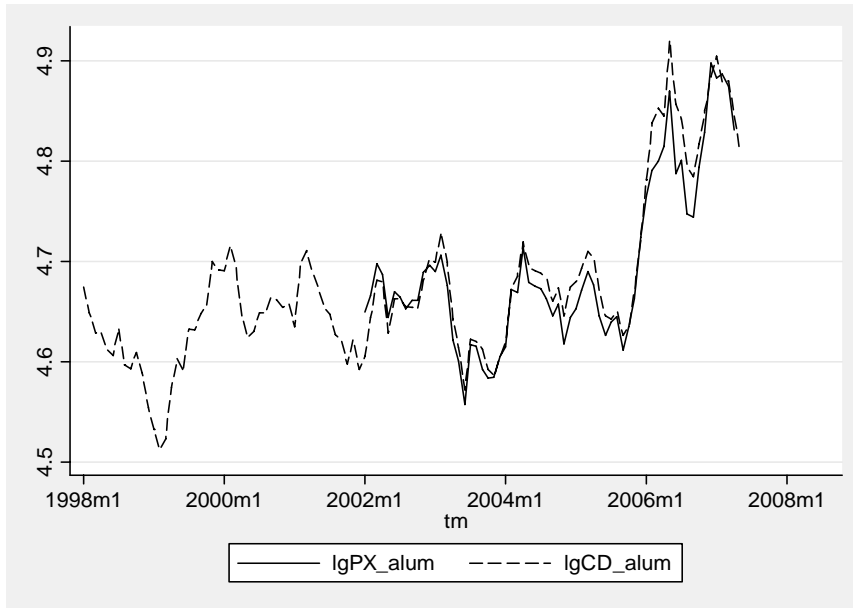(Down right) d- Impulse: US demand, response: exports price

Wood

Graph 18: Evolution of exports price and cost of production (log)

Graph 19: Exchange rate and exports price (variation in %)
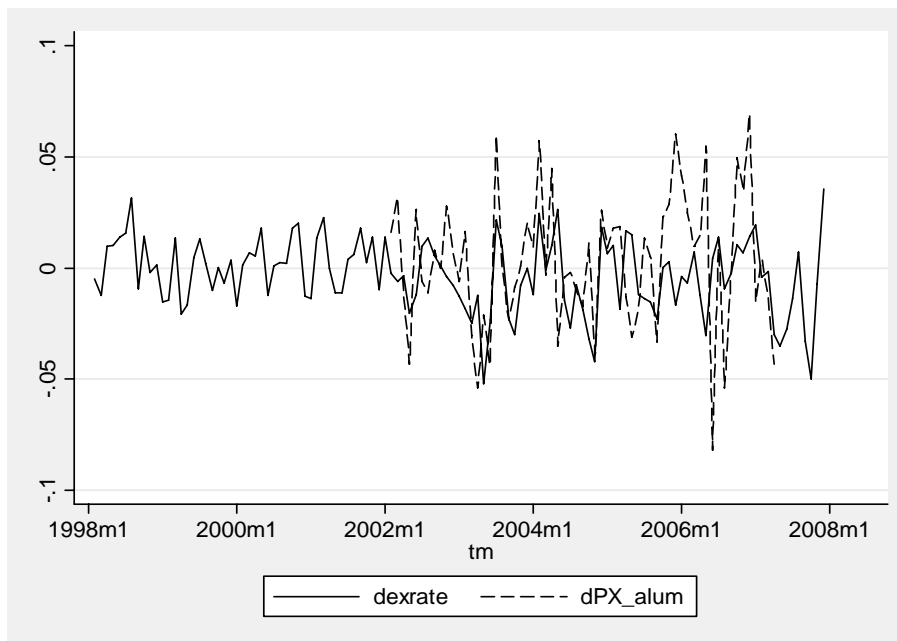
Graph 20: wood CIRFs
Model 1

(Up-left) a- Impulse: exchange rate, response: cost of production
(Up-right) b- Impulse: cost of production, response: exports price
(Down left) c- Impulse: exchange rate, response: exports price
(Down right) d- Impulse: US demand, response: exports price

Model 2

(Up-left) a- Impulse: exchange rate, response: cost of production
(Up-right) b- Impulse: cost of production, response: exports price
(Down left) c- Impulse: exchange rate, response: exports price
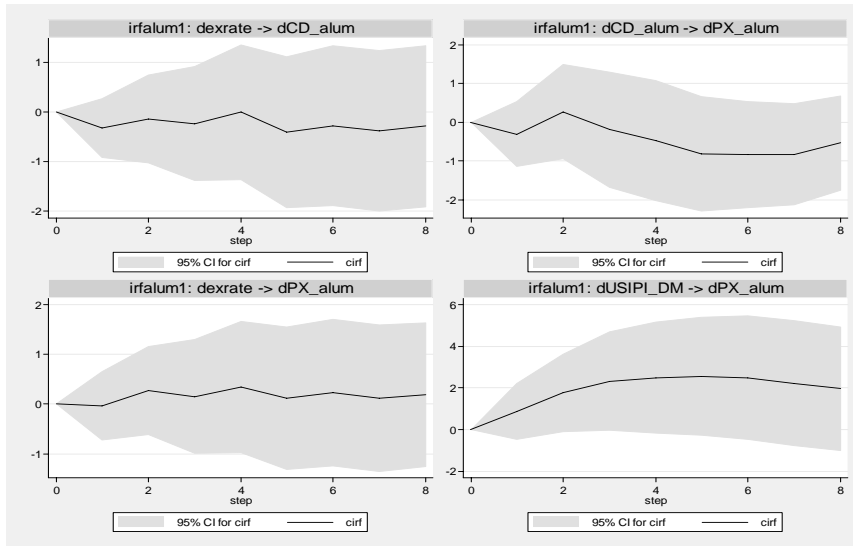(Down right) d- Impulse: US demand, response: exports price

Aluminum

Graph 21: Evolution of exports price and cost of production (log)

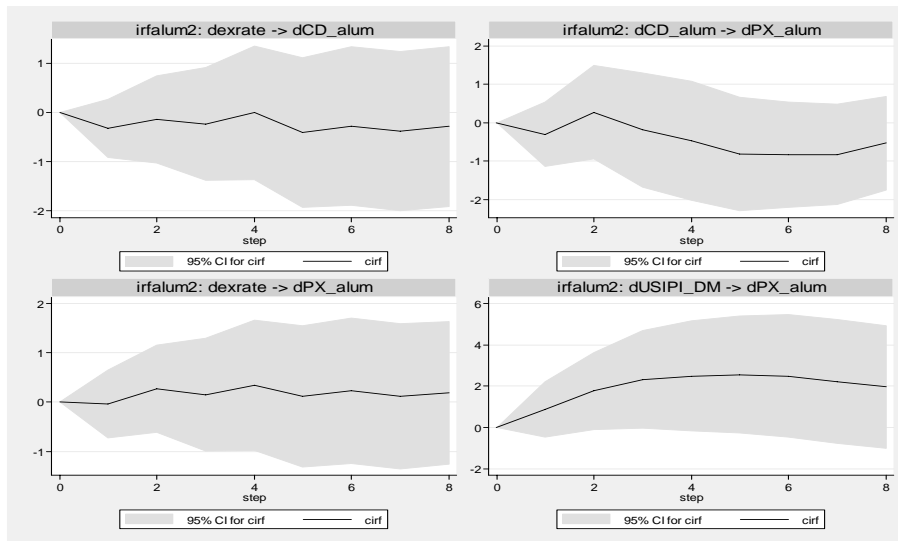**Graph 22:** Exchange rate and exports price (variation in %)

Graph 23: aluminum CIRFs
Model 1

(Up-left) a- Impulse: exchange rate, response: cost of production
(Up-right) b- Impulse: cost of production, response: exports price
(Down left) c- Impulse: exchange rate, response: exports price
(Down right) d- Impulse: US demand, response: exports price

Model 2

(Up-left) a- Impulse: exchange rate, response: cost of production
(Up-right) b- Impulse: cost of production, response: exports price
(Down left) c- Impulse: exchange rate, response: exports price
(Down right) d- Impulse: US demand, response: exports price