The Direct Effect on Norwegian Exports of a Disbandment of the Euro Area

An Econometric Analysis

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Preface

This thesis marks the end of the five-year masters programme in Economic Theory and Econometrics at the Department of Economics, University of Oslo.

I would like to express my gratitude to my supervisor Håvard Hungnes at Statistics Norway, for his useful comments, guidance and advice during the writing process, and to Statistics Norway for providing me with the necessary data.

A special thanks to my friends and family for their never-ending support and encouragement.

Any errors or inaccuracies in this thesis are my responsibility alone.

Kristine Bjørklund Tollefsen

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Abstract

The purpose of this thesis is to examine the direct effect on Norwegian exports of a hypothetical disbandment of the euro area. This is done by looking at what happened to Norwegian exports when the euro was introduced in two steps in 1999 and 2002. An export determination model is derived from theory, in which the amount of exports depends on foreign demand, relative prices and real capital in production. Step-dummy variables for the introduction of the euro are included in the model in order to account for the direct effect on Norwegian exports of the introduction of the euro.

The hypothesis is that the introduction of the euro led to substitution away from Norwegian products as a result of the lower transaction costs and the lower risk of exchange rate volatility within the currency union. In other words, the introduction of the euro gave Norwegian exporters a disadvantage as compared to their competitors in the euro area. If the euro area were to be disbanded, this disadvantage would disappear. Hence, in failing to reject the hypothesis, the conclusion will be that a disbandment of the euro area would lead to a positive direct effect on Norwegian exports.

Two versions of the model are examined, one in which the amount of exports in each period is determined only by demand side variables or only by supply side variables; and one whereby the amount of exports in each period is determined by both demand side variables and supply side variables at the same time. Three different production sectors of Norwegian industry are investigated - various industry products, metals and machinery products. An econometric analysis is performed in order to find a cointegrating relationship between the amount of exports and the explanatory variables.

The empirical analysis of the first version of the model produces coefficients with signs inconsistent with theory, and this version is therefore not a good fit to the data. The second version returns significant coefficients with signs consistent with theory, and proves to be a better fit. The empirical analysis of the second version fails to reject the hypothesis of a negative direct effect on Norwegian exports of the introduction of the euro for various industry products and machinery products. For metals, the direct effect is negative in 1999 and positive in 2002, and the aggregated effect is likely to not be significantly different from zero. The conclusion is thus, that a disbandment of the euro area would lead to an increase in the amount of exports of various industry products and machinery products, whereas the

direct effect on the amount of exports of metals is not likely to be significant. It is however important to note that the expected positive direct effect on Norwegian exports of various industry products and machinery products is likely to be outweighed by negative effects that are not discussed in this thesis.

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1 Introduction

The global financial crisis that emerged in 2007, and the economic downturn that followed, are major factors participating to the sovereign debt problems now occurring in many European countries. The countries that have experienced the greatest difficulties are Greece, Portugal, Ireland, Spain and Italy - all euro area countries.[1] These countries are finding it hard to borrow sufficient amounts in financial markets, and they are facing high interest rates on their government bonds. This is caused by uncertainty in the market of their ability to pay back their debt. Some of these countries, and Greece in particular, are facing the possibility of bankruptcy, which is likely to cause further problems for the euro area.

The European community, with Germany and France in the lead, are trying to come up with a solution to these pressing issues. They have among other things made provisions to grant emergency loans to individual member states, and the European Central Bank (ECB) has purchased government bonds in an attempt to appease soaring interest rates. They are however struggling to find a solution that will reassure the markets. Some people are questioning whether the European currency union will survive the atrocities the euro area countries are facing.

The European Union (EU) is Norway's largest trade partner, and according to Statistics Norway, countries in the EU are on the receiving end of most of our exports. In addition, exports accounted for as much as 41.9 per cent of Norway's GDP in 2010. Consequently, a change in Norwegian exports as a result of a disbandment of the euro area could potentially have large effects on the Norwegian economy.

In this paper, I want to investigate the direct effect on Norwegian exports of a hypothetical disbandment of the euro area. This will be done by looking at what happened when the euro was introduced. According to theory, as a result of the currency union, Norwegian firms exporting to the euro area have a disadvantage as compared to their competitors, when the competitors are euro area countries exporting to other countries using the euro as their currency. This is caused by the lower risk of exchange rate volatility and lower transaction costs within the currency union. Hence, when the euro was introduced, importing euro area countries might have substituted away from Norwegian products and towards products from

[1] Euro area: 17 countries using the euro as their currency.

other euro area countries. The hypothesis is thus that Norwegian exports decreased when the euro was introduced. This isolated euro effect will be the exact opposite in the case of a disbandment of the euro area.

In order to find the direct effect on Norwegian exports of the introduction of the euro, an econometric analysis will be performed. An export determination model will be developed from theory, in which Norwegian exports depend on foreign demand, relative prices and the real capital in production. Step-dummy variables for the introduction of the euro are included in this relation in order to account for the isolated euro effect, i.e. the direct effect on Norwegian exports. We will then try to find a cointegrating relationship. All estimations are performed using the econometric modelling package OxMetrics 6.20. If the estimated coefficients of the step-dummy variables are significantly different from zero, there is a demonstrated direct effect on the amount of exports as a result of the introduction of the euro. A demonstrated effect can tell us something about the effect of a disbandment, as the isolated euro effect of a disbandment will be the exact opposite of that of the introduction. We can thus make a conclusion on what will happen to Norwegian exports if the idea of a European currency union is abandoned.

Three different exporting sectors of Norwegian industry will be investigated – various industry products (diverse industriprodukter), metals (metaller) and machinery products (vekstedsprodukter). Because of differences between the production sectors, results are likely to differ from one sector to the other. For example, Norwegian exports of various industry products might be more differentiated from the equivalent products from competing exporting countries than what is the case for Norwegian exports of machinery products. As a result, the substitution away from Norwegian products might have been smaller for various industry products than for machinery products.

It is important to note that any positive direct effect on Norwegian exports of a disbandment of the euro area is likely to be outweighed by negative effects that are not discussed in this thesis. Such negative effects might be picked up by the other variables in the model, but it is difficult to determine the magnitude without further investigation.

The thesis is structured in the following way: Chapter 2 gives some background information on the euro. It elaborates on the introduction of the euro and the requirements each member country of the euro area had to fulfil to be accepted into the currency union. Chapter 3 describes the economic and theoretic framework. Here, the export determination model later used for estimation is developed. Chapter 4 elaborates on the terms and methods used in the empirical analysis. It is a summary of the relevant existing literature. In Chapter 5 the dataset and its time-series properties are presented. The econometric analysis and empirical results are presented in Chapter 6. Chapter 7 concludes.

2 The Euro

The euro is the official common currency in the 17 countries of the euro area.[2] It is in addition used in six small European states, and three of these states have an official agreement with the European Community about the use of the currency. This means that there are more than 330 million Europeans who use the euro on a daily basis; see the ECB's web pages for more details.

A common currency of the EU was a step towards greater stability of exchange rates and a higher level of coordination of monetary policies. There are two main reasons for why the EU has wanted to achieve this:

- They want to enhance and secure Europe's role in the monetary system of the world
- They want to create a truly unified single market within the EU

The first major step towards achieving this goal was the European Monetary System's (EMS) exchange rate mechanism (ERM) introduced in 1979; see Krugman and Obstfeld (2009, Ch. 20). It restricted the participating countries' currencies within certain fluctuation margins. These margins were adjusted several times over the years as it became clear that all participating countries were not experiencing booms at the same time, and that trying to match interest rates set by the central bank in a booming country could potentially send a non-booming country into a recession. The bands were as wide as ±15 per cent relative to a specified par value in the period between 1993 and 1999.

In 1999 and 2002, a currency union and a common European currency, the euro, replaced the ERM. On 1 January 1999, the euro was introduced as an accounting currency, meaning that all electronic payments were performed in euros. On 1 January 2002, bank notes and coins came into circulation. The euro then replaced the national currencies with fixed exchange rates. There were four main reasons for why the EU decided to move away from the EMS and introduce a common European currency:

- A single currency would remove costs of converting EMS currencies and eliminate the risk of currency realignments

[2] Euro area countries: Austria, Belgium, Cyprus, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Malta, the Netherlands, Portugal, Slovakia, Slovenia and Spain.

- It seemed to be the best solution for achieving both freedom of capital movements and fixed exchange rates
- Some felt that under the ERM, the macroeconomic goals of Germany were prioritised over the interests of other participating countries
- A common currency would be a permanent symbol of the European countries' willingness to prioritise cooperation over national interests

All EU member states, except Denmark and the United Kingdom, are obliged to join the currency union when they fulfil the requirements to do so. There are five such requirements, stipulated in Article 140(1) in the Consolidated version of the Treaty on the Functioning of the European Union, and they are known as the five convergence criteria:

1. Price stability; over the period of one year, average inflation rate is not to exceed 1.5 percentage points above that of the three best performing member states
2. Sound public finances; government deficit is not to exceed 3 per cent of GDP[3]
3. Sustainable public finances; government debt is not to exceed 60 per cent of GDP[4]
4. Exchange rate stability; participation in the ERM II for at least two years before entering the currency union without any serious tensions
5. Durability of convergence; over a period of one year, the average long-term interest rate is not to exceed 2 percentage points above that of the three best performing member states

These are the criteria that have to be fulfilled upon joining the euro area. After being accepted as a member however, a country is not required to fulfil these requirements at all times.

Furthermore, the Stability and Growth Pact, an agreement between the euro area members, contain criteria very similar to the five convergence criteria. This agreement is not binding, and at the moment, several euro area member states have public deficits exceeding 3 per cent of GDP and government debt exceeding 60 per cent of GDP. According to Eurostat (2012),

[3] Exceptions: If level has decreased continuously and substantially and is close to the required level, or if the excessive level is only temporary.
[4] Exception: If level has decreased continuously and substantially and is close to the required level.

the overall debt as a percentage of GDP in the 17 euro area member countries was 83.2 per cent in the third quarter of 2011. Greece was the euro area country with the highest debt with 159.1 per cent of GDP.

No member state has ever left the euro area. This said, the exit clause of Article 50(1) of the Consolidated version of the Treaty on European Union permits member states to leave the European Union, but it does not mention anything about leaving the euro area. However, Athanassiou (2009) states “that a Member State’s exit from EMU [European Monetary Union], without a parallel withdrawal from the EU, would be legally inconceivable”. In addition, Athanassiou (2009) argues that although an expulsion of a member state from the EU or the euro area might be feasible through indirect means, it would be “legally next to impossible” to do so.

3 Theoretic and Economic Framework

This chapter deals with the theoretic framework and the economic assumptions made when developing the general export relation later used for estimation purposes. Historically, there have been three prevalent approaches when developing an export model. The first alternative is the export demand model. It focuses solely on demand variables in the determination of amount of exports. Hence, it assumes that export is not constrained by supply side variables; see for example Landesmann and Snell (1989) and Anderton (1992). The second alternative, and the most common approach, is a model that incorporates both demand and supply side variables in the same export relation. Goldar (1989) called this the export determination model. The third and last approach is to specify two separate export functions, one for demand and one for supply, and simultaneously estimate this system of equations. See for example Brakman and Joosten (1987) and King (2001). This paper starts out with a general export demand model, and develops it into an export determination model with step-dummy variables for the introduction of the euro.

3.1 The General Export Demand Model

This part of the model is for the most part deducted from Boug and Dyvi (2008). One of the underlying assumptions for the model specification is that Norwegian products are exported to the world market, which is looked upon as one single importing country. In addition, there is one competing country that exports to the same importing country. The consumers in the importing country have a utility function that is separable in each product category, meaning that the consumption of one product category does not affect the utility obtained from consumption of other product categories. Each product category consists of two separate product groups, and again the consumption of one product group does not affect the utility obtained from consumption of the other product group. The two separable groups are

- the product group produced in the importing country; and
- the two imported product groups, i.e. the Norwegian product group and the product group produced in the competing country.

The aggregate utility function of consumption of the imported product category i is defined as

$$U_{Ai} = U_{Ai}(A_i^*, A_i) \quad i = 1, 2, \ldots, n, \qquad (3.1.1)$$

where A_i is the importing country's consumption of product category i produced by Norwegian producers, and A_i^* is the importing country's consumption of product category i produced by other foreign producers.

The budget constraint is given by

$$PMI_i \times MII_i = PAK_i \times A_i^* + PA_i \times A_i, \qquad (3.1.2)$$

where $PMI_i \times MII_i$ is the importing country's total expenditure on imports of product category i; MII_i is the import expenditure on product i measured in constant prices, and is a measure of foreign demand; PA_i is the import price and the Norwegian export price on A_i; and PAK_i is the import price on A_i^* and also the price Norwegian exporters are competing with.[5]

The conditional demand functions for Norwegian exports are found by maximizing the utility function in (3.1.1) with respect to the budget constraint in (3.1.2), for each separable product category i:

$$\text{Max} \quad U_{Ai} = U_{Ai}(A_i^*, A_i)$$

$$\text{s.t.} \quad PMI_i \times MII_i = PAK_i \times A_i^* + PA_i \times A_i.$$

This yields:

$$A_i = f_i(MII_i, \frac{PA_i}{PAK_i}), \qquad (3.1.3)$$

when we assume that PMI is a weighted index of PA and PAK, e.g. $PMI = PA^a PAK^{1-a}$. Norwegian exports of product category i are assumed to depend positively on foreign demand for the product, MII_i, and negatively on the relative prices, PA_i/PAK_i. The relative prices say something about the competitiveness of Norwegian products as compared to other foreign

[5] All variables are measured in NOK. PAK_i is derived from multiplying the price in the foreign currency ($PAKUTE_i$) with the exchange rate (*IMPKR44*). This variable is used for various industry products and machinery products. The competing price on metals is $PMET_i$ and is the IMF's metal price index converted to NOK. See Boug and Dyvi (2008, Ch. 3.2) for more details.

products. These explanatory variables are looked upon as exogenous when determining the amount of Norwegian exports.

The export relation in Equation (3.1.3) is assumed to be log-linear. This means that the estimated coefficients are interpreted as partial elasticities. They tell us by how many per cent Norwegian exports change when one of the explanatory variables changes by one per cent. By assuming this functional form, we restrict the price and income elasticities to be constant.

The general aggregated export relation for a specific production sector (subscript *i* is dropped, but subscript *t* is introduced for time) can be expressed as

$$a_t = \theta_0 + \theta_1 mii_t + \theta_2(pa - pak)_t + u_t, \tag{3.1.4}$$

where lower case letters indicate logs. As stated above, Norwegian exports will increase if foreign demand goes up, and decrease if the competitiveness of Norwegian products goes down as a result of higher relative prices. Hence, we hypothesise that the signs of the coefficients will be $\theta_1 > 0$ and $\theta_2 < 0$.

The export relation in Equation (3.1.4) can be looked upon as the long-run steady-state equilibrium. In the short-run however, it might not hold, as effects on exports resulting from changes in the explanatory variables might be gradual rather than instantaneous. There are several reasons for this. For one, consumers might be unsure of whether changes are permanent or temporary, and would because of this want to gradually adjust their decisions to new information. Secondly, a gradual adjustment might indicate that there is incomplete or asymmetric information, so that all consumers or importers will not find out about a change in relative prices at the same time, and thus might not change their consumption instantaneously. Thirdly, adjustment costs and contract obligations might limit the short-term substitution possibilities and thus cause a gradual adjustment. Because of this, it will be necessary to include lags of both the explanatory and perhaps also the dependent variable in the export relation.

Price homogeneity, both in the long run and in the short run, will be tested in Chapter 6. Long-run price homogeneity follows directly from theory, and short-run price homogeneity is tested for because it reduces the number of coefficients to be estimated. If short-run price homogeneity is rejected, this might indicate asymmetric information. Price heterogeneity in the short run might also be caused by delays in responses to price changes because of binding contracts. Rejection of price homogeneity in the long run indicates that the long-run relationship in Equation (3.1.4) is not correctly formulated, but it might also be caused by measurement error; see Benedictow (2000) for more details.

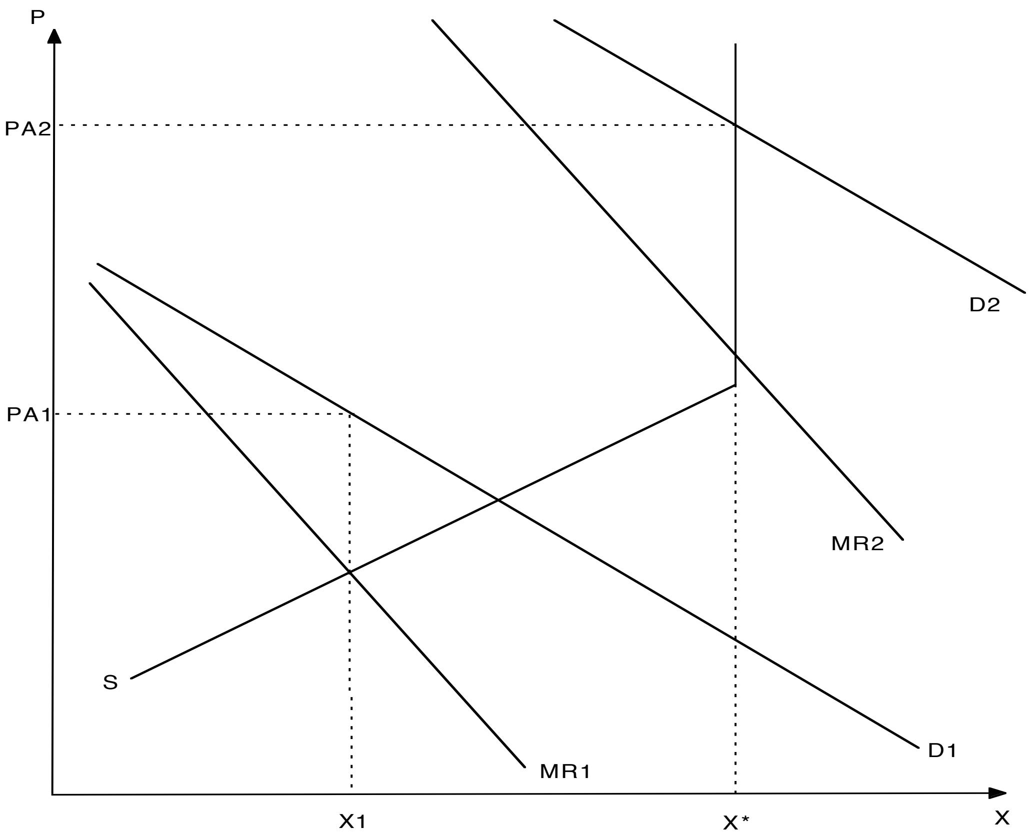
Also, by assumption, each producer is faced with a downward-sloping demand curve and an imperfectly competitive world market. Consequently, each producer acts as a monopolist.

3.2 The Export Determination Model

As in Benedictow (2000), we will assume that there is an identification problem, as exports are not solely determined by demand, but also by restrictions and constraints on the supply side.

Whenever the output capacity is not at its maximum level, demand, given the price, determines exports. Increasing the output capacity can be costly and take a lot of time, which makes it difficult for the output capacity to mimic all fluctuations in demand. Hence, we will assume that as demand and capital utilisation increases, exports will eventually be constrained by the output capacity. At this switching point in the export determination, the demand variables do no longer have all explanatory power, and the amount of exports is also partly determined by the supply side. The switching mechanism is depicted graphically in Figure 3.2.1.

Figure 3.2.1 Switching point mechanism



In the figure, X^* denotes the switching point for the producers. When output equals X^*, the producers cannot increase production without expanding the output capacity. At this point the supply curve (S), which is equal to the marginal cost, is vertical. When output is lower than X^*, say equal to X_1, the producer sets the price and demand determines output. Because each producer acts as a monopolist, the point where marginal revenue (MR1) equals marginal cost (S), determines price and quantity. If the demand curve (D1) shifts up or down, exports will increase or decrease respectively. When the marginal revenue curve (MR2) crosses the supply curve (S) in the vertical section however, fluctuations in demand do not affect the output because exports are now supply constrained. Fluctuations in demand will only lead to changes in price.

The supply of exports can be increased by expanding the output capacity. This would shift the supply curve (S) to the right, and as a result X*, the switching point from demand determined to capacity determined output, will be at a higher level of output. If a production sector is capital intensive, an increase in the output capacity requires large investments. This would both be time consuming and expensive, which makes it reasonable to assume that firms only undertake such investments when they judge the increase in demand to be permanent. Hence, when capacity utilisation is at its maximum level and the firms think that an increase in demand is only temporary, they will not expand the output capacity, and the export is constrained on the supply side; see Benedictow (2000) for more details.

In order to account for the possibility of exports being constrained by the output capacity, supply variables have to be included in the general export relation developed in Chapter 3.1. In the following, we will use a measure of the stock of real capital in production, *K*, as the supply side variable.

In the empirical analysis in Chapter 6, we will look at two specific cases, where

1) the amount of exports in each quarter is either determined only by supply side variables, or only by demand side variables; and

2) the amount of exports in each quarter is determined by both demand side variables and supply side variables at the same time.

For the first case, it is necessary to find out when exports are determined by demand and when they are determined by the output capacity. This can be done by looking at a measure for the capacity utilisation, *KAP*. *KAP* is calculated by Statistics Norway, and is an indicator based on data on capital stock and output. It is measured in per cent. Separate *KAP*s are calculated for the different production sectors; see Cappelen and von der Fehr (1986) for details. Whenever the capital utilisation is above a certain level, say for example 95 per cent, we will assume that exports are constrained by the output capacity. The supply and demand side variables are then weighted with indicator functions (i.e., functions taking the values 0 and 1 only) according to the activity level in the market.

The reasoning behind using indicator functions is that all producers in a particular sector by assumption reach the switching point at the same time, and are therefore faced with the same regime at all times. In reality, fluctuations in demand will probably not affect all firms in a specific sector at the same time, and their switching points might differ. If we however assume that these differences are relatively small, discrete weights will give a reasonable approximation of the dynamics between the two regimes. This assumption is motivated by Benedictow (2000). In Benedictow (2000), two versions of a two-regime model for the Norwegian export of primary metals are examined; one with indicator functions and one with continuous weights in front of the demand and supply side variables. After estimating the two versions however, he finds that on statistical grounds, it is not possible to discriminate between the two, as they both produce rather similar estimates for elasticities and residual standard errors.

When exports are determined by both supply side variables and demand side variables at the same time, i.e. the second case we want to investigate, the amount of exports is independent of the capacity utilisation, *KAP*.

In the first case, where export level is either determined by supply side variables or by demand side variables, represented by indicator functions, the long-term equilibrium export relation for a specific sector can be expressed as

1) $$a_t = D_t\theta_{0D} + S_t\theta_{0S} + D_t\theta_1 mii_t + D_t\theta_2(pa - pak)_t + S_t\theta_3 k_t + u_t, \quad (3.2.1)$$

where D_t is the demand side variable weight and S_t is the supply side variable weight. θ_3 is the elasticity of export with respect to the capital stock. Two constant terms are included in order to allow for potential differences in the constant terms for the two regimes. All other parameters have the same interpretation as in Chapter 3.1.

Whenever exports are constrained by foreign demand, the weight in front of the demand variables will be equal to one and the weight in front of the supply variable will be equal to zero: $D = 1$ and $S = 0$; and the constant term will be equal to θ_{0D}. Conversely, whenever exports are constrained by the output capacity, the weight in front of the demand variables will be equal to zero and the weight in front of the supply variable will be equal to one: $D = 0$ and $S = 1$; and the constant term will then be equal to θ_{0S}.

In the second case, where exports in each quarter are determined by both demand side variables and supply side variables at the same time, the long-term equilibrium export relation for a specific sector, can be expressed as

2) $$a_t = \theta_0 + \theta_1 mii_t + \theta_2(pa - pak)_t + \theta_3 k_t + u_t. \quad (3.2.2)$$

Again, θ_3 is the elasticity of export with respect to the capital stock, and all other parameters have the same interpretation as in Chapter 3.1.

For both cases, we hypothesise that an increase in the capital stock will lead to more Norwegian exports, i.e. $\theta_3 > 0$.

3.3 Introduction of the Euro

One of the benefits of a currency union is that the consumer markets within the union are likely to become more integrated and experience greater price transparency, increased competition and locational arbitrage (see e.g. Rose and Wincoop, 2001; Engel and Rogers, 2004). This was the underlying objective of the introduction of the euro as a common European currency. A higher degree of integration of markets in the EU, as a result of a common currency, is mainly caused by three factors:

- Lower transaction costs
- Lower exchange rate volatility
- Increased cross-border trade and thus potentially increased growth

This last effect, increased trade and hence potentially increased growth as a result of the introduction of the euro, might have given higher overall demand for products because of greater wealth in the euro area countries. This means that foreign demand might have increased, which would have a positive effect on Norwegian exports, as well as on the exports of the competing countries. This effect would be accounted for by an increase in the explanatory variable *MII*, foreign demand.

The two first effects, lower transaction costs and lower exchange rate volatility, will have resulted in a disadvantage for Norwegian producers exporting to the euro area as compared to their competitors, when the competitors are euro area countries trading with other euro area member states. Importing euro area member states might have wanted to import less of Norwegian goods and more goods from other euro area countries because of the lower transaction costs and the eliminated risk of exchange rate volatility the introduction of the euro brought with it. This indicates that Norwegian exports declined as a result of the introduction of the euro. This isolated long-term euro effect is not accounted for by the explanatory demand side variables *MII*, foreign demand, and *PA*/*PAK*, relative prices. We thus have to include a variable that will account for this direct effect.

The isolated euro effect on Norwegian exports of the introduction of the common European currency will be the exact opposite of the effect of a disbandment of the euro area. Hence, if we find an effect, we can say something about what will happen to Norwegian exports if the euro area is disbanded. This is caused by the fact that after a disbandment, the countries in the euro area would no longer have the advantage of lower transaction costs and lower risk of exchange rate volatility, and thus Norwegian exporters to the euro area do no longer have a disadvantage compared to their competitors in the euro area.

In order to investigate the direct effect of the introduction of the euro on Norwegian exports, we include step-dummy variables in the general export determination relation. As the euro was introduced in two steps, we will include one step-dummy that is equal to one from 1st January 1999 (and zero otherwise), and one step-dummy that is equal to one from 1st January 2002 (and zero otherwise). For the two different cases described in Chapter 3.2, the long-term export relation for a particular sector can now be expressed as

1) $$a_t = D_t\theta_{0D} + S_t\theta_{0S} + D_t\theta_1 mii_t + D_t\theta_2(pa - pak)_t + S_t\theta_3 k_t + \theta_4 DUM1999(1)_t + \theta_5 DUM2002(1)_t + u_t, \quad (3.3.1)$$

2) $$a_t = \theta_0 + \theta_1 mii_t + \theta_2(pa - pak)_t + \theta_3 k_t + \theta_4 DUM1999(1)_t + \theta_5 DUM2002(1)_t + u_t, \quad (3.3.2)$$

where $DUM1999(1)_t$ is the step-dummy for the introduction of the euro as an accounting currency, and $DUM2002(1)_t$ is the step-dummy for the introduction of euro notes and coins. Because of the lower transaction costs and lower volatility of exchange rates within the currency union, and thus possible substitution away from Norwegian products, we hypothesise that the isolated euro effect on Norwegian exports of the introduction of the euro was negative: $\theta_4 < 0$ and $\theta_5 < 0$. This means that if the empirical analysis fails to reject this hypothesis, a disbandment of the euro area would have a positive direct effect on Norwegian exports.

4 Topics in Time-Series Econometrics

We want to find a cointegrating relationship in order to correctly describe the long-run relationship between Norwegian exports and the explanatory variables foreign demand, relative prices and real capital. In this chapter, we will explain and elaborate on the concepts and methods used in connection with the econometric modelling of this cointegrating relationship. It is a summary of the relevant existing literature.

4.1 Stationarity

Consider the following simple regression model:

$$Y_t = \alpha X_t + u_t. \tag{4.1.1}$$

This model is said to be balanced if the dependent variable, Y_t, exhibits the same properties as the explanatory variable, X_t. According to Granger (1990), having a balanced model is a necessary condition for Ordinary Least Squares (OLS) estimation to produce non-spurious and interpretable results. Having a balanced regression model and the concept of stationary variables is closely connected.

A time-series variable is said to be stationary if the stochastic properties of the variable do not change over time:

$$E(X_t) = \mu \quad \forall t \tag{4.1.2}$$

$$cov(X_t, X_{t-i}) = E(X_t - \mu)(X_{t-i} - \mu) = \gamma_i \quad \forall t, i. \tag{4.1.3}$$

In other words, its mean and variance should be constant, and the covariance should only depend on the time difference between two observations.

Many economic time-series data are trending, suggesting that shocks are permanent rather than temporary. This means that the mean and the variance of these series are changing over time, and they are thus not stationary. However, if the series is made stationary by removing the trend, it is said to be trend stationary. The trend can be removed by regressing the variable on time and letting the residuals form a new stationary and trend-free variable. Most macroeconomic data are however characterised by a random walk even after deterministic trends have been removed. In the presence of non-stationarity, statistics such as the t- and F-statistics will not exhibit their traditional characteristics, and inference based on these statistics might be invalid; see e.g. Harris (1995, Ch. 2)

Any non-stationary variable can be made stationary by differencing. If a variable becomes stationary after being differenced once, it is said to be integrated of order 1, denoted as I(1), and by definition it contains one unit root. A variable that needs to be differentiated *d* times to become stationary, is said to be integrated of order *d*, denoted I(*d*), and contains *d* unit roots. Hence, a stationary variable is said to be integrated of order 0, denoted I(0), and contains no unit roots.

If both X_t and Y_t in Equation (4.1.1) are I(0), i.e. they are both stationary, the regression model is balanced. In general, any linear combination of two stationary variables is itself stationary. This means that the residual term, u_t, is stationary whenever X_t and Y_t in Equation (4.1.1) are stationary. Stationarity of the residual term is a necessary condition for OLS to produce Best Linear Unbiased Estimators (BLUE).

A linear combination of two variables that are both integrated of order *d*, will generally be balanced. In most cases however, the residual term will only be stationary and I(0) if both variables in the model are I(0). A balanced model with variables that are all I(*d*), with $d \geq 1$, will usually yield residuals that are I(*d*), and whenever the residuals are not stationary, OLS estimators are not BLUE.

4.2 Cointegration

In some cases, a particular linear combination of two variables that are both integrated of order 1, will be I(0), and thus yield stationary residuals. The two non-stationary variables are then said to be cointegrated. Separately, the two non-stationary variables will meander extensively, resulting in non-constant means and variances, but certain disequilibrium forces will tend to keep the two variables from drifting too far apart, so that a particular linear combination of the two variables yields a constant mean and variance. In other words, cointegration as a concept mimics a long-run equilibrium or a steady state of the economy.

Examples of such potentially cointegrated variables are imports and exports, and short- and long-term interest rates; see e.g. Kennedy (2008, Ch. 19) for more details.

Formally, and in accordance with Engle and Granger (1987), if the two time series Y_t and X_t in Equation (4.1.1) are both I(*d*), and there exists a coefficient α that yields a residual term, $u_t = Y_t - \alpha X_t$, that is of a lower order of integration than Y_t and X_t, say I(*d*–*b*), where *b*>0, then Y_t and X_t are cointegrated of order (*d*, *b*), denoted CI(*d*, *b*). The cointegrating coefficient α is necessarily unique. If it were not unique, this would imply that both X_t and Y_t were I(*d*–*b*).

When there are more than one explanatory variable, i.e. $\boldsymbol{X_t}$ is a vector consisting of all the exogenous variables, we call $\boldsymbol{\alpha}$ the cointegrating vector. $\boldsymbol{\alpha}$ is not necessarily unique. If $\boldsymbol{\alpha}$ is not unique, but there is a number *s* of linearly independent cointegrating vectors, we say that *s* is the cointegrating rank of the variables. This means that there are *s* possible combinations of the dependent and the explanatory variables that render the residual term stationary; see e.g. Davidson (2000, Ch. 15).

When cointegration between Y_t and X_t exists, OLS is appropriate and inference based on the corresponding t- and F-statistics will be valid for the parameters in the cointegrating relationship, even though the individual time series are non-stationary.

4.3 Testing for Unit Roots: Augmented Dickey-Fuller (ADF) Test

As previously stated, if a variable contains unit roots, it is non-stationary and OLS regressions might give spurious results, unless there exists cointegration between the variables. Therefore, it is important to test for stationarity of the variables of interest. Most tests for stationarity are actually tests for non-stationarity, because they are tests for unit roots. In the following we will use the Augmented Dickey-Fuller test, derived in Dickey and Fuller (1979), when testing for unit roots.

Consider a time series, Y_t, that follows an autoregressive process of order p (AR(p)):

$$Y_t = \mu + \gamma t + \beta_1 Y_{t-1} + \beta_2 Y_{t-2} + \cdots + \beta_p Y_{t-p} + u_t, \tag{4.3.1}$$

where t is a time trend. This can be rewritten as

$$\Delta Y_t = \mu + \gamma t + \beta^* Y_{t-1} + \sum_{i=1}^{p-1} \lambda_i \Delta Y_{t-i} + u_t, \qquad (4.3.2)$$

where $\beta^* = \sum_{j=1}^{p} \beta_j - 1$ and $\lambda_i = -\sum_{k=i+1}^{p} \beta_k$.

Note, that in order to decide the order, p, of the AR-process, it is necessary to inspect the characteristics of the residual term, u_t. If there is evidence of autocorrelation between the error terms, one possible solution is to increase the order p until the residuals are reduced to white noise.

The order of integration of Y_t is tested in the following way:

$$H_0: \beta^* = 0, \;\; H_1: \beta^* < 0.$$

To test this null hypothesis, a t-test must be constructed. The computed t-statistic will under non-stationarity not follow the standard t-distribution however, but rather a so-called Dickey-Fuller distribution. This DF-distribution will depend on whether or not a trend, the t-term, is included in Equation (4.3.2). Rejection of the null hypothesis leads to the conclusion of stationarity of the variable Y_t. In failing to reject the null, we conclude that the variable Y_t contains unit roots and is at least integrated of order one. If this is the case, the variable is differenced a second time, and we test for unit roots in the variable ΔY_t. If the null hypothesis of existing unit roots is rejected, we can conclude that ΔY_t is stationary, and hence the variable Y_t is integrated of order 1, $Y_t \sim \mathrm{I}(1)$. If we fail to reject the null, ΔY_t contains unit roots, and is at least integrated of order one, and hence Y_t is at least integrated of order two; see e.g. Harris (1995, Ch. 3) for more details.

4.4 Error Correction Models (ECMs)

Consider the following model:

$$Y_t = \alpha_0 + \boldsymbol{\alpha_1} \boldsymbol{X}_t + u_t. \tag{4.4.1}$$

The type of relationship between Y_t and $\boldsymbol{X}_t$ described in Equation (4.4.1) only considers the long-term equilibrium relationship between the variables. A good time-series model should however describe both the long-term equilibrium and the short-term dynamics simultaneously. In the short run, Y_t can be influenced by the past, and in order to account for this, lagged values of both Y and $\boldsymbol{X}$ have to be added to the regression equation. Error Correction Models (ECMs), made popular by Engle and Granger (1987), are useful for this, as they incorporate both the short-term dynamics and the effects of deviations from the long-run equilibrium. ECMs also allow us to analyse exogenous shocks over several time periods.

Consider an autoregressive distributed lag model of order one (ARDL(1))[6]:

$$Y_t = \alpha_0 + \boldsymbol{\alpha_1 X_t} + \boldsymbol{\alpha_2 X_{t-1}} + \beta Y_{t-1} + u_t, \tag{4.4.2}$$

where Y_t is I(1) and $\boldsymbol{X_t}$ is a vector of explanatory variables that are all I(1). This is a necessary implicit condition when looking at ECMs. Assume that a long-term equilibrium occurs at $Y_t = Y^*$, $\boldsymbol{X_t} = \boldsymbol{X}^*$ and $u_t = 0$ for all *t*. This gives:

$$Y^* = \alpha_0 + \boldsymbol{\alpha_1 X}^* + \boldsymbol{\alpha_2 X}^* + \beta Y^*, \tag{4.4.3a}$$

and thus

$$Y^* = \theta_0 + \boldsymbol{\theta_1 X}^*, \tag{4.4.3b}$$

where $\theta_0 = \frac{\alpha_0}{1-\beta}$ is the long-run constant and $\boldsymbol{\theta_1} = \frac{\boldsymbol{\alpha_1}+\boldsymbol{\alpha_2}}{1-\beta}$ is the long-run coefficient of $\boldsymbol{X}$. Whenever we are not in the long-run equilibrium, Equation (4.4.3) will not hold with equality, and there will be a non-zero difference between Y^* and $(\theta_0 + \boldsymbol{\theta_1 X}^*)$. This is called the error correction term, denoted $\xi = Y^* - \theta_0 - \boldsymbol{\theta_1 X}^*$.

[6] This derivation of an ECM can easily be extended to autoregressive distributed lag models of higher orders.

An ECM can be derived from Equation (4.5.1) in the following way:

$$\Delta Y_t = \alpha_0 - (1-\beta)Y_{t-1} + (\boldsymbol{\alpha_1} + \boldsymbol{\alpha_2})\boldsymbol{X_{t-1}} + \boldsymbol{\alpha_1}\Delta \boldsymbol{X_t} + u_t \quad (4.4.4a)$$

$$= \alpha_0 - \rho Y_{t-1} + \boldsymbol{\mu X_{t-1}} + \boldsymbol{\alpha_1}\Delta \boldsymbol{X_t} + u_t, \quad (4.4.4b)$$

where $\rho = -(1-\beta)$ and $\boldsymbol{\mu} = \boldsymbol{\alpha_1} + \boldsymbol{\alpha_2}$. This can be rewritten as

$$\Delta Y_t = \rho(Y_{t-1} - \theta_0 - \boldsymbol{\theta_1 X_{t-1}}) + \boldsymbol{\alpha_1}\Delta \boldsymbol{X_t} + u_t \quad (4.4.5a)$$

$$= \rho\xi_{t-1} + \boldsymbol{\alpha_1}\Delta \boldsymbol{X_t} + u_t. \quad (4.4.5b)$$

The ECM in Equation (4.4.5b) shows that changes in the dependent variable, given by ΔY_t, is explained by two components:

- changes in the explanatory variables, given by $\Delta \boldsymbol{X_t}$; and
- correction of last period's deviation from the long-run equilibrium, given by ξ_{t-1}.

The elements in the $\boldsymbol{\alpha_1}$ vector represent the short-term effects on the dependent variable, *Y*, of changes in the explanatory variables in the vector ***X***. The elements in $\boldsymbol{\theta_1}$ represent the long-term effects of changes in the variables in ***X***. ρ is called the equilibrium correction coefficient and tells us that if *Y* deviated from its fundamental value by one per cent in the last period, the correction in the current period will be given by $(100\times\rho)$ per cent. Therefore, when using quarterly data, this implies that it will take approximately -log2/log$(1-\rho)$ quarters to correct half of the deviation of one per cent from the long-run equilibrium.

When remembering that both Y_t and $\boldsymbol{X_t}$ contain one unit root, and if we assume that they are cointegrated with each other, we see that Equation (4.4.5b) only contains stationary variables (ΔY_t, $\Delta \boldsymbol{X_t}$ and ξ_{t-1}), and is thus not a spurious regression.

As explained in Chapter 3, the dependent variable in the model used in this paper is Norwegian exports. The log of exports is assumed to contain one unit root and thus to be integrated of order one, $a \sim \mathrm{I}(1)$. Hence, the change in log of exports is assumed to be stationary, $\Delta a \sim \mathrm{I}(0)$. The explanatory variables are also assumed to contain one unit root.[7] Thus, in the short run, only stationary variables will influence the change in the amount of

[7] See appendix B for more details.

goods being exported. In the long run however, non-stationary variables also matter and would have to be included in the export relation. In order for the equation representing the ECM to be balanced, we will have to prove that the long-run export relation is stationary. It is only stationary if the non-stationary variables are cointegrated.

This is in accordance with Granger's Representation theorem presented in Engle and Granger (1987), which states that observing cointegration between non-stationary variables is equivalent to there existing one or more error correction relations between these variables.

4.5 Estimation of Error Correction Models

An implicit assumption in the estimation method we use in Chapter 6, is that there exists only one unique cointegrating vector, and that it is the left-hand side variables that are responsible for the equilibrium correction.

The model given by Equation (4.4.4) is estimated using OLS, and we test the hypothesis $H_0: \rho = 0$ against $H_1: \rho < 0$. Note again that the computed t-statistic will not follow the standard t-distribution; see e.g. Patterson (2000, Ch. 8). Evidence of $\rho \neq 0$ and rejection of the null hypothesis suggests that there exists an error correction mechanism, and from Granger's Representation theorem we know that this implies the existence of a cointegrating relationship between the variables in the long-term export relation. In other words, because of Granger's Representation Theorem, we do not have to prove the existence of a cointegrating relationship before estimating the ECM.

5 Data

The empirical analysis in Chapter 6 is performed using quarterly data collected and calculated by Statistics Norway. The dataset is dated from 1978(1) to 2011(4). In order to allow for transformations and lags however, the sample period used for estimation is 1980(1) - 2010(4).

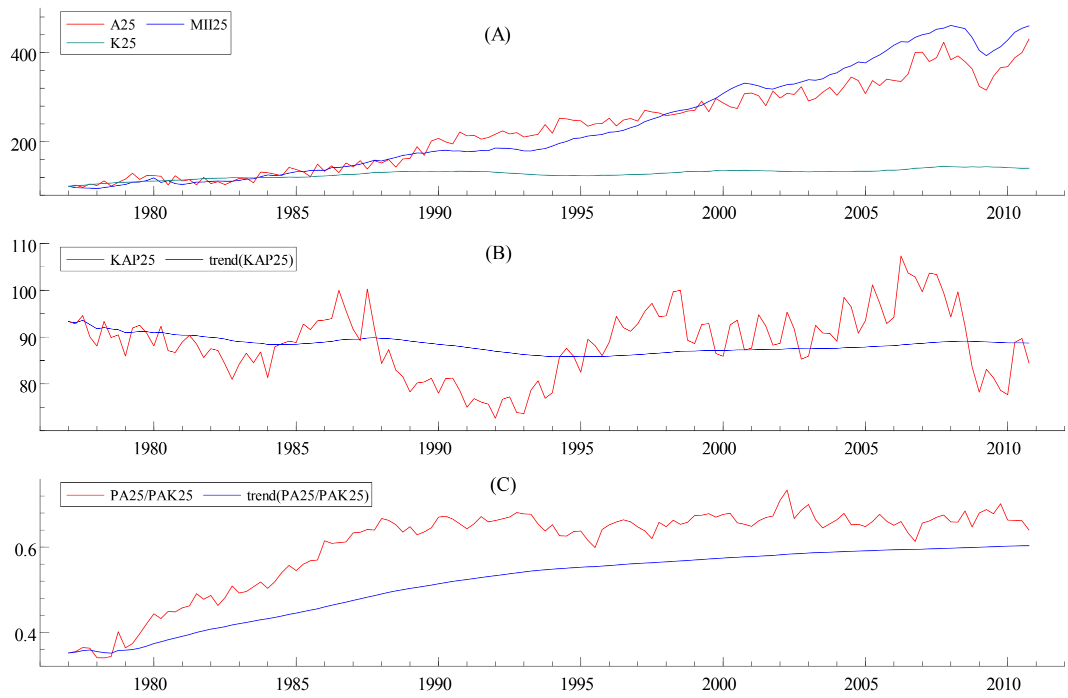
The dependent variable is amount of exports, *A*. It is calculated by deflating a value series of exports by the export price index, *PA*. The explanatory variables are *MII*, *PA*/*PAK* (or *PA*/*PMET* in the case for metals) and *K*. *MII* is an indicator for demand in the world market, measured in constant prices. *PA* is a price index for Norwegian exports, measured in NOK. *PAK* is a price index for competing products on the world market, measured in NOK. *PMET* is the price index for metals, calculated by the International Monetary Fund (IMF), also measured in NOK. *K* is the stock of real capital in the different industries. In addition, we will use a measure for the capital utilisation, *KAP*, in the different sectors as an indication of whether the amount of exports is decided by constraints on the supply side or on the demand side. *KAP* is calculated by Statistics Norway using the Modified Wharton-Method; see Cappelen and von der Fehr (1986) for more details.

As mentioned before, we will look at three different products – various industry products, metals and machinery products. The code 25 indicates various industry products, codes 43 and 30 indicate metals, and codes 46 and 45 indicate machinery products. See Appendix A for detailed sources and data definitions.

5.1 Various Industry Products

Figure 5.1.1 gives a historic description of the data.

Figure 5.1.1 Historic Development, Various Industry Products



Note: In Figure 5.1.1 (A), all variables are normalised to 100 in 1978(1). The trends in Figures 5.1.1 (B) and (C) are calculated as moving averages in OxMetrics.

Figure 5.1.1 (A) shows that exports, *A*, and foreign demand, *MII*, have been increasing with roughly the same rate over the given period. In the period 1995 to 2006, foreign demand was however growing with a higher rate than exports. As a result, Norwegian exports to the world market decreased relative to exports from competing countries. The lower growth in exports might for instance have been caused by higher relative prices, *PA*/*PAK*, or constraints on the output capacity. Furthermore, real capital in production, *K*, is relatively constant throughout the given period. Figure 5.1.1 (B) shows that the trend in the capacity utilisation, *KAP*, was rather flat throughout the whole period. The trend is slightly decreasing up until 1995, and slightly increasing, but less so, after 1995. From Figure 5.1.1 (C) we see that the trend in relative prices, *PA*/*PAK*, was increasing throughout the whole period, indicating that Norwegian exports became less and less attractive on the world market, in terms of prices, as compared to exports from competing countries. This indicates that the lower share of

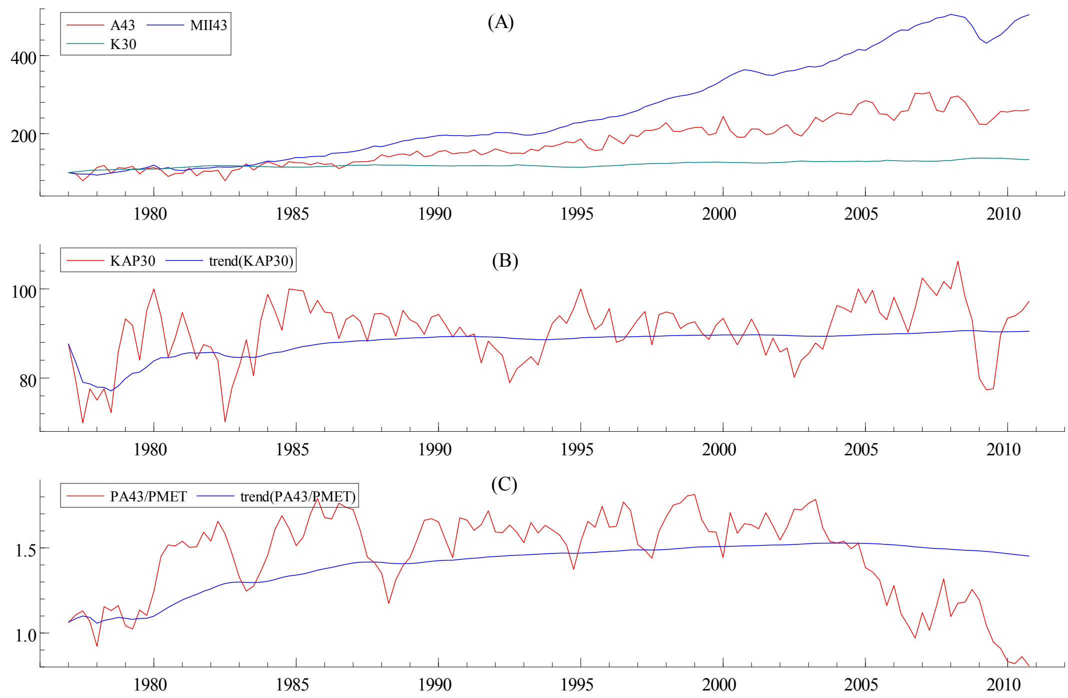
Norwegian exports on the world market could have been caused by both increasing relative prices and constraints on the output capacity.

We have graphed the different data series and performed ADF-tests in order to investigate their time-series properties. The results are presented in Appendix B. For various industry products, the tests show that the log-form of exports, *a25*, foreign demand, *mii25*, and real capital in production, *k25*, are all non-stationary and integrated of order one, I(1). The log-form of relative prices, (*pa25* – *pak25*), is according to the tests stationary, but in the empirical analysis in Chapter 6, it will be treated as a variable integrated of order one, I(1).

5.2 Metals

Figure 5.2.1 gives a historic description of the data.

Figure 5.2.1 Historic Development, Metals



Note: In Figure 5.2.1 (A) all variables are normalised to 100 in 1978(1). The trends in Figures 5.2.1 (B) and (C) are calculated as moving averages in OxMetrics.

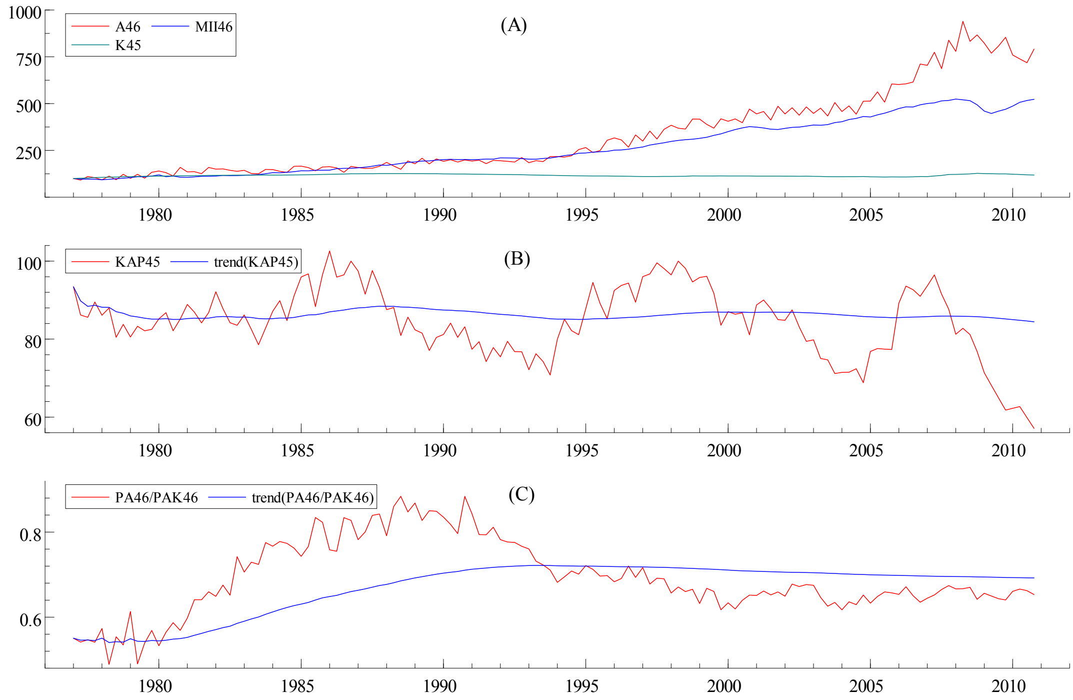
From Figure 5.2.1 (A) we see that throughout the whole period, exports, *A*, were growing at a lower rate than foreign demand, *MII*. As mentioned above, this might have been caused by increasing relative prices, *PA*/*PMET*, or by constraints on the output capacity. It might however also be caused by a market elasticity that is lower than one. The real capital in production, *K*, is relatively constant throughout the whole period. Figure 5.2.1 (B) shows an increasing trend of capital utilisation, *KAP*, and we see that the level of capital utilisation is close to and even higher than 100 per cent in several quarters. This could be an indication of capital-intensive production, and of reluctance on the producers' side to expand the output capacity because of the high costs to do so. From Figure 5.2.1 (C) we see that there was an increasing trend in relative prices, *PA*/*PMET*, up until 2005. After 2005, the trend was slightly decreasing, which means that Norwegian metals became relatively more attractive on the world market, as compared to products from competing exporting countries. The decreasing market share held by Norwegian exporters can in other words have been caused by all three factors mentioned above, but it is more likely to have been caused by constraints on the output capacity than by increasing relative prices, as relative prices were in fact decreasing after 2005.

According to the ADF-tests presented in Appendix B, the log-form of foreign demand for Norwegian metals, *mii43*, and relative prices, (*pa43 - pmet*), are both non-stationary and integrated of order 1, I(1). The tests indicate that the log-form of Norwegian exports of metals *a43*, and the real capital in production, *k30*, are both stationary variables. They will however be treated as variables integrated of order one in the empirical analysis in Chapter 6.

5.3 Machinery Products

Figure 5.3.1 gives a historic description of the data.

Figure 5.3.1 Historic Development, Machinery Products



Note: In Figure 5.3.1 (A) all variables are normalised to 100 in 1978(1). The trends in Figures 5.3.1 (B) and (C) are calculated as moving averages in OxMetrics.

Figure 5.3.1 (A) shows that after 1995, exports, *A*, have been growing at a higher rate than foreign demand, *MII*. This indicates that the market elasticity is larger than one, or that exports in this period were not restricted by constraints on the output capacity or increasing relative prices. We also see that real capital in production, *K*, has been relatively constant throughout the given period. Figure 5.3.1 (B) shows that there has been a rather flat trend in capital utilisation, *KAP*. From Figure 5.3.1 (C) we see that relative prices, *PA*/*PAK*, experienced an increasing trend up until 1995, and a decreasing trend after that. In other words, the competitiveness of Norwegian exports, in terms of prices, decreased before 1995, and increased after 1995. This indicates that the increasing share on the world market obtained by Norwegian exporters after 1995 was a result of lower prices on Norwegian exports relative to exports from competing countries.

The ADF-tests presented in Appendix B show that the log-form of Norwegian exports of machinery products, *a46*, and foreign demand, *mii46*, are non-stationary and integrated of order one. The log-form of relative prices, (*pa46 – pak46*), is according to the tests integrated of order 2. Furthermore, the log-form of real capital in the Norwegian production of machinery products, *k45*, is according to the tests stationary. Both of these variables will however be treated as variables integrated of order one in the empirical analysis in Chapter 6.

6 Empirical Results

In this chapter, the econometric modelling and the empirical results are presented. All estimations are performed using the econometric modelling package OxMetrics; see Doornik and Hendry (2006).

Equations (3.3.1) and (3.3.2) assume that changes in the explanatory variables, foreign demand, relative prices and real capital in production, affect the dependent variable, the amount of exports, instantaneously. As mentioned previously, this is not likely to hold in reality. Economic agents take time to adjust to changes, and the main reasons for this are binding contracts, asymmetric information and uncertainty of whether the changes are permanent or not. A good time-series model should describe both the long-term equilibrium and the short-term dynamics. Equations (3.3.1) and (3.3.2) can be looked upon as the long-term equilibrium relationship between the amount of exports and the explanatory variables for the two different cases we want to investigate. In order to account for the short-term dynamics, we add lags of both the dependent and the explanatory variables.

In Chapter 5, the time-series properties of the different variables were described. As stated, we will treat all variables as non-stationary variables integrated of order 1. As the variables are not stationary, OLS estimation of Equations (3.3.1) and (3.3.2) may not give stationary residual terms, and any inference based on the t- and F-statistics from such estimations would thus not be valid. However, because of the properties of the time-series variables, an error correction model would produce stationary residuals and valid inference. Such a model includes lags of the dependent and the explanatory variables, and would thus describe both the short-term dynamics and the long-term equilibrium in a satisfactory way.

In accordance with Chapter 4.5, we will now derive the simplest form of the error correction model later used for estimation.[8] As in Chapter 4.5, consider an autoregressive distributed lag model of order one (ARDL(1)):

$$a_t = \alpha_0 + \alpha_1 mii_t + \alpha_2 (pa - pak)_t + \alpha_3 k_t + \alpha_4 mii_{t-1} \tag{6.0.1}$$

$$+\alpha_5 (pa - pak)_{t-1} + \alpha_6 k_{t-1} + \beta a_{t-1} + \alpha_7 DUM1999(1)_t$$

[8] For simplicity, we have not included the indicator functions in this simple model. These can however easily be added to the model, and we will do so later.

$$+\alpha_8 DUM2002(1)_t + u_t.$$

A long-term equilibrium occurs when $a_t = a_{t-1}$, $mii_t = mii_{t-1}$, $k_t = k_{t-1}$, $(pa - pak)_t = (pa - pak)_{t-1}$, and $u_t = 0$ for all t. This gives:

$$(1-\beta)a = \alpha_0 + (\alpha_1 + \alpha_4)\times mii + (\alpha_2 + \alpha_5)\times(pa - pak) \qquad (6.0.2a)$$

$$+(\alpha_3 + \alpha_6)\times k + \alpha_7 DUM1999(1) + \alpha_8 DUM2002(1).$$

Rewriting gives:

$$a = \frac{\alpha_0}{(1-\beta)} + \frac{(\alpha_1+\alpha_4)}{(1-\beta)}\times mii + \frac{(\alpha_2+\alpha_5)}{(1-\beta)}\times(pa - pak) + \frac{(\alpha_3+\alpha_6)}{(1-\beta)}\times k \qquad (6.0.2b)$$

$$+\frac{\alpha_7}{(1-\beta)}\times DUM1999(1) + \frac{\alpha_8}{(1-\beta)}\times DUM2002(1)$$

$$a = \theta_0 + \theta_1 mii + \theta_2(pa - pak) + \theta_3 k + \theta_4 DUM1999(1) \qquad (6.0.2c)$$

$$+\theta_5 DUM2002(1),$$

where $\theta_0 = \frac{\alpha_0}{(1-\beta)}$ is the long run constant term; $\theta_1 = \frac{(\alpha_1+\alpha_4)}{(1-\beta)}$ is the long run coefficient of *mii*, foreign demand; $\theta_2 = \frac{(\alpha_2+\alpha_5)}{(1-\beta)}$ is the long run coefficient of (*pa* – *pak*), relative prices; $\theta_3 = \frac{(\alpha_3+\alpha_6)}{(1-\beta)}$ is the long run coefficient of *k*, real capital in production; and $\theta_4 = \frac{\alpha_7}{(1-\beta)}$ and $\theta_5 = \frac{\alpha_8}{(1-\beta)}$ are the long run coefficients of the dummy variables for the introduction of the euro. For the model to be stable, $(1-\beta)$ has to be strictly positive; more precisely, the value of $(1-\beta)$ has to be between 0 and 2. From theory we know that $\theta_1 > 0$, $\theta_2 < 0$ and $\theta_3 > 0$, as an increase in foreign demand or in real capital in production has a positive effect on the amount of exports, and an increase in relative prices affects the amount of exports negatively. We also know that $\theta_4 < 0$ and $\theta_5 < 0$, as we hypothesise that the introduction of the euro had a negative effect on Norwegian exports. Furthermore, as $(1-\beta) > 0$, we see that α_7 will have the same sign as θ_4, and that α_8 will have the same sign as θ_5, i.e. $\alpha_7 < 0$ and $\alpha_8 < 0$.

Whenever the economy is not in the long-run equilibrium, there will be a non-zero difference between *a*, exports, and the explanatory variables:

$$\xi = a - \theta_0 - \theta_1\times mii - \theta_2\times(pa - pak) - \theta_3\times k - \theta_4 DUM1999(1) \qquad (6.0.3)$$

$-\theta_5 DUM2002(1)$.

This is called the error correction term.

An error correction model can be derived from Equation (6.0.1) in the following way:

$$\Delta a_t = \alpha_0 - (1-\beta)a_{t-1} + (\alpha_1+\alpha_4)mii_{t-1} + (\alpha_2+\alpha_5)(pa-pak)_{t-1} \quad (6.0.4a)$$

$$+(\alpha_3+\alpha_6)k_{t-1} + \alpha_1\Delta mii_t + \alpha_2\Delta(pa-pak)_t + \alpha_3\Delta k_t$$

$$+\alpha_7 DUM1999(1)_t + \alpha_8 DUM2002(1)_t + u_t.$$

This can be rewritten as

$$\Delta a_t = \alpha_0 + \rho a_{t-1} + \mu_1 mii_{t-1} + \mu_2(pa-pak)_{t-1} + \mu_3 k_{t-1} \quad (6.0.4b)$$

$$+\alpha_1\Delta mii_t + \alpha_2\Delta(pa-pak)_t + \alpha_3\Delta k_t + \alpha_7 DUM1999(1)_t$$

$$+\alpha_8 DUM2002(1)_t + u_t,$$

where $\rho = -(1-\beta)$; $\mu_1 = (\alpha_1+\alpha_4)$; $\mu_2 = (\alpha_2+\alpha_5)$; and $\mu_3 = (\alpha_3+\alpha_6)$. This can further be simplified to

$$\Delta a_t = \alpha_0 + \rho(a_{t-1} - \theta_1 mii_{t-1} - \theta_2(pa-pak)_{t-1} - \theta_3 k_{t-1} \quad (6.0.4c)$$

$$-\theta_4 DUM1999(1)_t - \theta_5 DUM2002(1)_t) + \alpha_1\Delta mii_t$$

$$+\alpha_2\Delta(pa-pak)_t + \alpha_3\Delta k_t + +u_t.$$

As $\rho = -(1-\beta) < 0$ and $\mu_i = -\rho\theta_i$ for *i* = 1,2,3, μ_i will have the same sign as θ_i. In other words, $\mu_1 > 0$, $\mu_2 < 0$ and $\mu_3 > 0$.

The lag structure of the correct error correction model is unknown, and we thus start out with a general dynamic version of (3.3.1) and (3.3.2) with five lags. For the two different cases we want to look at, the general dynamic version for a specific export sector is represented by the following error correction models:

1) For demand determined by either demand side variables or supply side variables:

$$\Delta a_t = D_t\alpha_{0D} + S_t\alpha_{0S} + \sum_{i=1}^{5}\gamma_{t-i}\Delta a_{t-i} + \rho a_{t-1} \quad (6.0.5a)$$

$$+\sum_{i=0}^{5} D_{t-i}\alpha_{1t-i}\Delta mii_{t-i} + \sum_{i=1}^{5} D_{t-i}\alpha_{2t-i}\Delta(pa-pak)_{t-i}$$

$$+\sum_{i=0}^{5} S_{t-i}\alpha_{3t-i}\Delta k_{t-i} + D_{t-1}\mu_1 mii_{t-1}$$

$$+D_{t-1}\mu_2(pa-pak)_{t-1} + S_{t-1}\mu_3 k_{t-1} + \alpha_7 DUM1999(1)_t$$

$$+\alpha_8 DUM2002(1)_t + \sum_{q=1}^{3}\lambda_q DUM(q)_t + u_t.$$

This can alternatively be written as

$$\Delta a_t = D_t\alpha_{0D} + S_t\alpha_{0S} + \sum_{i=1}^{5}\gamma_{t-i}\Delta a_{t-i} + \rho(a_{t-1} - D_{t-1}\theta_1 mii_{t-1} \quad (6.0.5b)$$

$$-D_{t-1}\theta_2(pa-pak)_{t-1} - S_{t-1}\theta_3 k_{t-1} - \theta_4 DUM1999(1)_t$$

$$-\theta_5 DUM2002(1)_t) + \sum_{i=0}^{5} D_{t-i}\alpha_{1t-i}\Delta mii_{t-i}$$

$$+\sum_{i=1}^{5} D_{t-i}\alpha_{2t-i}\Delta(pa-pak)_{t-i} + \sum_{i=0}^{5} S_{t-i}\alpha_{3t-i}\Delta k_{t-i}$$

$$+D_{t-1}\mu_1 mii_{t-1} + D_{t-1}\mu_2(pa-pak)_{t-1} + S_{t-1}\mu_3 k_{t-1}$$

$$+\sum_{q=1}^{3}\lambda_q DUM(q)_t + u_t.$$

2) For export determined by both demand side variables and supply side variables at the same time:

$$\Delta a_t = \alpha_0 + \sum_{i=1}^{5}\gamma_{t-i}\Delta a_{t-i} + \rho a_{t-1} + \sum_{i=0}^{5}\alpha_{1t-i}\Delta mii_{t-i} \quad (6.0.6a)$$

$$+\sum_{i=1}^{5}\alpha_{2t-i}\Delta(pa-pak)_{t-i} + \sum_{i=0}^{5}\alpha_{3t-i}\Delta k_{t-i} + \mu_1 mii_{t-1}$$

$$+\mu_2(pa-pak)_{t-1} + \mu_3 k_{t-1} + \alpha_7 DUM1999(1)_t$$

$$+\alpha_8 DUM2002(1)_t + \sum_{q=1}^{3}\lambda_q DUM(q)_t + u_t.$$

This can alternatively be written as

$$\Delta a_t = \alpha_0 + \sum_{i=1}^{5}\gamma_{t-i}\Delta a_{t-i} + \rho(a_{t-1} - \theta_1 mii_{t-1} \quad (6.0.6b)$$

$$-\theta_2(pa-pak)_{t-1} - \theta_3 k_{t-1} - \theta_4 DUM1999(1)_t$$

$$-\theta_5 DUM2002(1)_t) + \sum_{i=0}^{5}\alpha_{1t-i}\Delta mii_{t-i}$$

$$+ \sum_{i=1}^{5} \alpha_{2t-i} \Delta(pa - pak)_{t-i} + \sum_{i=0}^{5} \alpha_{3t-i} \Delta k_{t-i}$$

$$+ \sum_{q=1}^{3} \lambda_q DUM(q)_t + u_t.$$

As previously noted, lower case letters indicate logs. Δ represents a one-period change in a given variable. $DUM1999(1)_t$ and $DUM2002(1)_t$ are the step-dummy variables representing the introduction of the euro. $DUM(q)_t$ for q = 1,2,3 are seasonal dummy variables, and u_t is a residual term that is assumed to be white noise.

Note that we do not include the change in relative prices for the current period *t* as an explanatory variable, as Chapter 3.2 argues that price and quantity are determined at the same time, and an inclusion could thus lead to simultaneity bias in the estimated coefficients.[9]

The "general-to-specific" estimation approach is adopted in order to minimise any risk of misspecification of the dynamic relationship; see Davidson *et. al* (1978) for more details. First, the general model in Equations (6.0.5a) and (6.0.6a) is estimated. Then, insignificant variables and variables with coefficients inconsistent with theory are removed before the model is re-estimated. Note that one has to be careful when excluding variables, as an increase in efficiency might come at the cost of misspecification. We apply Autometrics in OxMetrics 6.20 for the general-to-specific estimation. Impulse dummies are included in the final model (as the "Dummy Saturation" setting is used); see Appendix C for more details.

In the general model in Equations (6.0.5) and (6.0.6), price homogeneity in the short run and in the long run is implicitly assumed. When estimating, we will test these restrictions. As in Benedictow (2000), short-run price homogeneity is tested by including the variables $D_t \Delta pa_t$ and Δpa_t in the regressions for the cases of indicator functions and no indicator functions respectively. Long-run price homogeneity is tested by including the variables $D_{t-1} pa_{t-1}$ and pa_{t-1} in the regressions. If the coefficients of these variables are significantly different from zero, price homogeneity is rejected. We will use the t-values as test statistics.

[9] See Figure 3.2.1 for more details.

6.1 Various Industry Products

6.1.1 With Indicator Functions

As mentioned, we have set the switching point at a level of 95 per cent capital utilisation. This means that in the case of either supply restricted or demand restricted output, the amount of Norwegian exports is determined by demand side variables whenever the capital utilisation is below 95 per cent, and by supply side variables whenever the capital utilisation is equal to or higher than 95 per cent.

The general-to-specific estimation approach gives us the following error correction model:

$$\Delta a_t = \underset{(0.37)}{1.10}\, D_t + \underset{(0.37)}{1.15}\, S_t - \underset{(0.07)}{0.31}\, \Delta a_{t-1} + \underset{(0.07)}{0.24}\, \Delta a_{t-4} \tag{6.1.1.1}$$

$$+ \underset{(0.20)}{0.54}\, D_t \Delta mii_t + \underset{(0.22)}{0.63}\, D_t \Delta mii_{t-1} - \underset{(0.16)}{0.43}\, D_t \Delta (pa - pak)_{t-3}$$

$$- \underset{(0.03)}{0.09}\, a_{t-1} - \underset{(0.06)}{0.06}\, D_{t-1} mii_{t-1} + \underset{(0.09)}{0.08}\, D_{t-1}(pa - pak)_{t-1}$$

$$- \underset{(0.03)}{0.03}\, S_{t-1} k_{t-1} + \underset{(0.02)}{0.02}\, DUM1999(1)_t + \underset{(0.02)}{0.01}\, DUM2002(1)_t$$

$$- \underset{(0.17)}{0.67}\, D_t \Delta pa_t + \underset{(0.14)}{0.13}\, D_{t-1} pa_{t-1} - \underset{(0.02)}{0.05}\, DUM(1)_t - \underset{(0.01)}{0.06}\, DUM(2)_t$$

$$- \underset{(0.01)}{0.07}\, DUM(3)_t - \underset{(0.05)}{0.14}\, I{:}\,1986(3)_t - \underset{(0.05)}{0.13}\, I{:}\,1987(3)_t$$

$$- \underset{(0.05)}{0.13}\, I{:}\,1991(4)_t$$

Method: OLS 1980(1) – 2010(4) $R^2 = 0.73$ $F(20,103) = 13.58$ [0.000] $\sigma = 0.04$

RSS = 0.20 for 21 parameters and 124 observations

Residual misspecification tests:			
AR 1-5	$F(5,98)$	=	1.56 [0.18]
ARCH 1-4	$F(4,116)$	=	0.27 [0.90]
Normality	$\chi^2(2)$	=	0.81 [0.67]
Hetero	$F(28,92)$	=	0.76 [0.79]
Hetero-X	$F(79,41)$	=	1.30 [0.18]
RESET23	$F(2,101)$	=	0.16 [0.85]

Significance of euro-dummy variables:

$DUM1999(1)_t$	t-value	=	1.16
$DUM2002(1)_t$	t-value	=	0.66

Tests for restrictions of price homogeneity:

$D_t \Delta pa_t$	t-value	=	- 4.00
$D_{t-1} pa_{t-1}$	t-value	=	0.91

The standard errors are given in parentheses below the estimated parameters. $I{:}yyyy(q)_t$ are impulse dummy variables for outliers in year yyyy, quarter q. R^2 is the squared multiple correlation coefficient; F is an F-test of whether R^2 is equal to zero; σ is the residual standard error; and RSS is the residual sum of squares. Standard tests on the residuals are also reported. AR 1 - 5 is a test for no autocorrelation; ARCH, hetero and hetero-X are tests for no heteroskedasticity; the normality test tests the distribution of the residuals; and RESET23 tests for no functional form misspecification; see Doornik and Hendry (2006) for more details. None of these tests are significant.

The t-value of $D_t \Delta pa_t$ is higher than 1.96 in absolute value, which means that the coefficient is significantly different from zero, and thus price homogeneity in the short run is rejected.[10] Rejection of short-run price homogeneity is likely to be caused by the fact that economic agents take time to adjust to new information, as a result of binding contracts and asymmetric information. Long-run price homogeneity is not rejected.

The stability of the estimated coefficients is examined in Appendix D, where the estimated coefficients in every quarter of the sample period, together with their 95 per cent confidence intervals, are graphically illustrated. We see that most coefficients are stable throughout the sample period. Also, there are no big outliers, as all residuals are within the ±2SE bands. The break point Chow test does not reject parameter constancy.

There exists an error correction mechanism and thus a cointegrating relationship, as the coefficient of a_{t-1} ($\hat{\rho}$) is significantly lower than zero. We do however see that the

[10] The critical t-value for a two-sided test on a 5 per cent significance level is equal to 1.96.

coefficients of $D_{t-1}mii_{t-1}$, $D_{t-1}(pa-pak)_{t-1}$ and $S_{t-1}k_{t-1}$ all have signs opposite of what is predicted by theory. They are also not significantly different from zero.[11] The coefficients of the step-dummy variables for the introduction of the euro also have signs inconsistent with the hypothesis, and from the reported t-statistics we see that they are not significantly lower than zero. Furthermore, as all these coefficients have the opposite sign of what is predicted by theory, we see that the model is not a good fit to the data, and we thus choose not to look at the long-run relationship between exports and the explanatory variables.

6.1.2 Without Indicator Functions

The general-to-specific estimation method for the case where exports are determined by both demand side and supply side variables at the same time, gives the following error correction model:

$$\begin{aligned}\Delta a_t = &- \underset{(2.55)}{0.21} + \underset{(0.06)}{0.31}\ \Delta a_{t-4} + \underset{(0.22)}{1.05}\ \Delta mii_t - \underset{(0.92)}{4.99}\ \Delta k_{t-3} \qquad (6.1.2.1)\\ &- \underset{(0.06)}{0.45}\ a_{t-1} + \underset{(0.10)}{0.52}\ mii_{t-1} + \underset{(0.09)}{0.05}\ (pa-pak)_{t-1} + \underset{(0.21)}{0.18}\ k_{t-1}\\ &- \underset{(0.02)}{0.07}\ DUM1999(1)_t - \underset{(0.02)}{0.05}\ DUM2002(1)_t - \underset{(0.18)}{0.59}\ \Delta pa_t\\ &- \underset{(0.15)}{0.14}\ pa_{t-1} + \underset{(0.05)}{0.16}\ I{:}1980(4)_t\end{aligned}$$

Method: OLS   1980(1) – 2010(4) $R^2 = 0.67$ F(12,111) = 19.09 [0.000]   σ = 0.05

RSS = 0.24   for 13 parameters and 124 observations

[11] This can be seen by calculating the t-value, which is equal to $\frac{\hat{\beta}}{se(\hat{\beta})}$, where $\hat{\beta}$ is the estimated coefficient, and $se(\hat{\beta})$ is the standard error of this coefficient. For the coefficient to be significantly different (lower or higher according to the hypothesis based on theory) from zero, the absolute value of the calculated t-value has to be greater than the critical t-value, which for one-sided tests is equal to 1.645 on the 5 per cent significance level (assuming large number, i.e. > 120, of degrees of freedom).

Residual misspecification tests:			
AR 1-5	$F(5,106)$	=	1.92 [0.10]
ARCH 1-4	$F(4,116)$	=	0.69 [0.60]
Normality	$\chi^2(2)$	=	4.56 [0.10]
Hetero	$F(20,102)$	=	0.69 [0.83]
Hetero-X	$F(56,66)$	=	0.70 [0.91]
RESET23	$F(2,109)$	=	0.17 [0.84]

Significance of euro-dummy variables:

$DUM1999(1)_t$	t-value	=	- 3.03
$DUM2002(1)_t$	t-value	=	- 2.49

Tests for restrictions of price homogeneity:

Δpa_t	t-value	=	- 3.35
pa_{t-1}	t-value	=	- 0.94

Above, we see that none of the reported residual misspecification tests are significant. Price homogeneity in the short run is however rejected, as the coefficient of Δpa_t is significantly different from zero. This is again likely to be caused by the fact that economic agents take time to adjust to new information, because of asymmetric information and binding contracts. pa_{t-1} is not significant, and thus price homogeneity in the long run is not rejected.

The coefficient of a_{t-1} is significantly lower than zero, meaning that there exists an error correction mechanism, and thus a cointegrating relationship. The coefficients of mii_{t-1}, k_{t-1}, $DUM1999(1)_t$ and $DUM2002(1)_t$ all have signs consistent with theory, and they are all, with the exception of the coefficient of k_{t-1}, significantly different from zero. Moreover, the sign of the coefficient of $(pa - pak)_{t-1}$ is the opposite of what is predicted by theory, and it is also not significantly different from zero.

When looking at the recursive graphics in Appendix D, we see that most coefficients are stable throughout the sample period and significantly different from zero. We also see that there are no big residual outliers, as all residuals are within the 95 per cent confidence intervals. In addition, the break point Chow test does not reject parameter constancy.

The long-run equilibrium export relation can be found by dividing the coefficients $\hat{\mu}_1$, $\hat{\mu}_3$, $\hat{\alpha}_7$ and $\hat{\alpha}_8$ by $-\hat{\rho}$. We will then obtain the long-run coefficients $\hat{\theta}_1$, $\hat{\theta}_3$, $\hat{\theta}_4$ and $\hat{\theta}_5$. Note that as the coefficient of relative prices in Equation (6.1.2.1) has the opposite sign of what theory predicts it will not be included in the long-run equilibrium relation. Dividing through by $-\hat{\rho}$ gives:

$$a = 1.14mii + 0.4k - 0.16DUM1999(1) - 0.11DUM2002(1). \qquad (6.1.2.2)$$

In Equation (6.1.2.2), the first two coefficients are interpreted as the partial long-run elasticities of exports, A, with respect to demand, *MII*, and real capital in production, *K*. This means that a one per cent increase in foreign demand would lead to a 1.14 per cent increase in the equilibrium amount of exports; and a one per cent increase in real capital in production would lead to a 0.4 per cent increase in the equilibrium amount of exports. It is important to note that in this case, real capital in production, *k*, is not significant, even though it is reported in this long-run equilibrium export relation.

The coefficients in front of the two step-dummy variables are interpreted as the change in the long run equilibrium amount of exports as a result of the introduction of the euro. We see that the introduction of the euro as an accounting currency reduced the equilibrium amount of Norwegian exports by 0.16 per cent. The introduction of euro coins and notes further reduced the equilibrium amount by 0.11 per cent. In other words, the introduction of the euro decreased the equilibrium amount of Norwegian exports of various industry products by (0.16 + 0.11) = 0.27 per cent. This decrease in Norwegian exports was caused by the lower transaction costs and the lower risk of exchange rate fluctuations within the European currency union, resulting in importing euro area countries substituting away from Norwegian products. In other words, the introduction of the euro gave Norwegian exporters a disadvantage as compared to their competitors in the euro area. If the euro area is disbanded and there no longer is a currency union within the EU, this disadvantage would disappear, and the long-run equilibrium amount of Norwegian exports is expected to increase by 0.27 per cent.

6.2 Metals

6.2.1 With Indicator Functions

When the amount of exports of metals each period is determined either only by supply side variables or only by demand side variables, the general-to-specific estimation method gives the following error correction model:

$$\Delta a_t = \underset{(0.24)}{0.15}\, D_t + \underset{(0.24)}{0.17}\, S_t - \underset{(0.07)}{0.42}\, \Delta a_{t-1} - \underset{(0.07)}{0.21}\, \Delta a_{t-2} - \underset{(0.06)}{0.29}\, \Delta a_{t-3} \qquad (6.2.1.1)$$

$$+ \underset{(0.22)}{0.62}\, D_{t-3}\Delta mii_{t-3} - \underset{(0.09)}{0.24}\, D_{t-1}(pa - pmet)_{t-1}$$

$$- \underset{(0.08)}{0.21}\, D_{t-2}(pa - pmet)_{t-2} - \underset{(1.66)}{10.45}\, S_{t-3}\Delta k_{t-3} - \underset{(0.03)}{0.001}\, a_{t-1}$$

$$- \underset{(0.02)}{0.03}\, D_{t-1} mii_{t-1} + \underset{(0.04)}{0.0004} D_{t-1}(pa - pmet)_{t-1} - \underset{(0.01)}{0.02}\, S_{t-1}k_{t-1}$$

$$- \underset{(0.02)}{0.03}\, DUM1999(1)_t + \underset{(0.02)}{0.07}\, DUM2002(1)_t - \underset{(0.12)}{0.17}\, D_t\Delta pa_t +$$

$$+ \underset{(0.05)}{0.002}\, D_{t-1}pa_{t-1} + \underset{(0.01)}{0.03}\, DUM(1)_t - \underset{(0.01)}{0.04}\, DUM(3)_t - \underset{(0.04)}{0.22}\, I{:}1982(3)_t$$

$$+ \underset{(0.05)}{0.13}\, I{:}1982(4)_t + \underset{(0.05)}{0.11}\, I{:}1996(1)_t + \underset{(0.05)}{0.19}\, I{:}1996(4)_t$$

$$+ \underset{(0.04)}{0.17}\, I{:}2000(1)_t - \underset{(0.05)}{0.13}\, I{:}2005(4)_t - \underset{(0.05)}{0.18}\, I{:}2006(1)_t$$

$$- \underset{(0.05)}{0.18}\, I{:}2007(4)_t$$

Method: OLS   1980(1) – 2010(4) $R^2 = 0.80$ F(26,97) = 14.47 [0.000] $\sigma = 0.04$

RSS = 0.17   for 27 parameters and 124 observations

Residual misspecification tests:			
AR 1-5	$F(5,92)$	=	2.59 [0.03]*
ARCH 1-4	$F(4,116)$	=	1.09 [0.37]
Normality	$\chi^2(2)$	=	0.14 [0.93]
Hetero	$F(31,84)$	=	0.94 [0.57]
Hetero-X	$F(104,11)$	=	1.38 [0.29]
RESET23	$F(2,95)$	=	0.33 [0.72]

Significance of euro-dummy variables:			
$DUM1999(1)_t$	t-value	=	- 1.73
$DUM2002(1)_t$	t-value	=	3.55

Tests for restrictions of price homogeneity:			
$D_t \Delta pa_t$	t-value	=	- 1.44
$D_{t-1} pa_{t-1}$	t-value	=	0.05

We see that the test for no autocorrelation is significant, meaning that the residuals show signs of autocorrelation. None of the other misspecification tests are significant. Price homogeneity neither in the long run nor in the short run is rejected. The recursive graphics in Appendix D show stability of most of the coefficients throughout the sample period, no great residual outliers, and no rejection of parameter constancy according to the break point Chow test.

The coefficient of a_{t-1} is not significantly lower than zero, meaning that there does not exist an error correction mechanism and no cointegrating relationship. Also, the coefficients of $D_{t-1}mii_{t-1}$, $D_{t-1}(pa - pmet)_{t-1}$, $S_{t-1}k_{t-1}$ and $DUM2002(1)_t$ all have signs inconsistent with theory, and only the coefficient of $DUM2002(1)_t$ is significantly different from zero. Therefore, the coefficient of $DUM1999(1)_t$ is the only coefficient with the correct sign, and it is also significantly lower than zero. By implication, the model with indicator functions is not a good fit to the data, and we thus choose not to take a closer look at the long-run equilibrium export relation for Norwegian metals.

6.2.2 Without Indicator Functions

When both demand side variables and supply side variables determine the amount of exports of metals in each period, the general-to-specific estimation method gives the following error correction model:

$$\Delta a_t = \underset{(2.93)}{4.08} + \underset{(0.26)}{1.22}\ \Delta mii_t + \underset{(0.26)}{0.76}\ \Delta mii_{t-5} - \underset{(0.07)}{0.54}\ a_{t-1} \tag{6.2.2.1}$$

$$+ \underset{(0.06)}{0.40}\ mii_{t-1} - \underset{(0.04)}{0.03}\ (pa - pmet)_{t-1} - \underset{(0.25)}{0.08}\ k_{t-1}$$

$$- \underset{(0.02)}{0.07}\ DUM1999(1)_t + \underset{(0.02)}{0.05}\ DUM2002(1)_t$$

$$- \underset{(0.11)}{0.18}\ \Delta pa_t - \underset{(0.05)}{0.08}\ pa_{t-1} - \underset{(0.01)}{0.06}\ DUM(3)_t$$

$$- \underset{(0.06)}{0.18}\ I{:}1980(3)_t - \underset{(0.05)}{0.25}\ I{:}1982(3)_t + \underset{(0.05)}{0.17}\ I{:}2000(1)_t$$

Method: OLS 1980(1) – 2010(4) $R^2 = 0.65$ $F(14,109) = 14.41$ [0.000] $\sigma = 0.05$

RSS = 0.29 for 15 parameters and 124 observations

Residual misspecification tests:

AR 1-5	F(5,104)	=	1.77 [0.12]
ARCH 1-4	F(4,116)	=	2.97 [0.02]*
Normality	$\chi^2(2)$	=	0.93 [0.63]
Hetero	F(19,101)	=	0.88 [0.61]
Hetero-X	F(47,73)	=	1.37 [0.11]
RESET23	F(2,107)	=	3.45 [0.04]*

Significance of euro-dummy variables:

$DUM1999(1)_t$	t-value	=	- 3.03
$DUM2002(1)_t$	t-value	=	2.17

Tests for restrictions of price homogeneity:

Δpa_t	t-value	=	- 1.63
pa_{t-1}	t-value	=	- 1.75

The test report shows signs of both heteroskedasticity and misspecification, as both the ARCH 1-4 and the RESET23 tests are significant. Price homogeneity is not rejected in the long run nor in the short run. The recursive estimations in Appendix D show constancy of most coefficients throughout the sample period. There are signs of a structural change in 1994-95, as there are residual outliers around this time, and also a break above the one per cent significance level of the break point Chow test.

We see that the coefficient of a_{t-1} is significantly lower than zero, and there thus exists an error correction mechanism and a cointegrating relationship. The coefficients of mii_{t-1}, $(pa-pmet)_{t-1}$ and $DUM1999(1)_t$ have signs consistent with theory, and with the exception of the coefficient of $(pa-pmet)_{t-1}$, they all are significantly different from zero. The sign of the coefficient of k_{t-1} is inconsistent with theory, and it is also not significantly different from zero. The coefficient of $DUM2002(1)_t$ also has the wrong sign according to our hypothesis, but this coefficient is however significantly different from zero.

As in Chapter 6.1.2, the long-run equilibrium export relation is found by dividing through by $-\hat{\rho}$. This gives:

$$a = 0.74mii - 0.06(pa - pmet) - 0.13DUM1999(1) \qquad (6.2.2.2)$$

$$+0.09DUM2002(1).$$

Real capital in production is not included in this long-run equilibrium relation as the sign of its estimated coefficient in Equation (6.2.2.1) is inconsistent with theory. We have however included both step-dummy variables for the introduction of the euro, even though the coefficient of the latter of these has the wrong sign according to our hypothesis.

In the long-run equilibrium export relation, the two first coefficients are interpreted as elasticities of exports with respect to foreign demand, *MII*, and relative prices, *PA/PMET*, respectively. This means that if foreign demand increases by one per cent, the equilibrium amount of Norwegian exports will increase by 0.74 per cent; and if relative prices increase by one per cent, the equilibrium amount of exports will decrease by 0.06 per cent. Again, it is important to note that the estimation in Equation (6.2.2.1) shows that relative prices as an explanatory variable is not significant in this case, but we still choose to include it in the long-run equilibrium export relation.

The two last coefficients are interpreted as the direct effect on the equilibrium amount of Norwegian exports of metals as a result of the introduction of the euro. We see that the introduction of the euro as an accounting currency resulted in a decrease in exports of 0.13

per cent. On the other hand, the introduction of euro notes and coins resulted in a 0.09 per cent increase in exports. This is inconsistent with our hypothesis, but the overall effect of the introduction of the euro is still negative, as (- 0.13 + 0.09) = - 0.04 per cent. This effect might however not be significantly different from zero. We can thus conclude that if the euro area is disbanded and there no longer is a currency union within the EU, the direct effect on the long-run equilibrium amount of Norwegian exports of metals is not expected to be significantly different from zero.

6.3 Machinery Products

6.3.1 With Indicator Functions

In the case of either demand restricted or supply restricted amount of exports of machinery products, the general-to-specific estimation method gives the following error correction model:

$$\Delta a_t = -\underset{(0.26)}{0.09}\, D_t - \underset{(0.26)}{0.07}\, S_t - \underset{(0.07)}{0.39}\, \Delta a_{t-1} + \underset{(0.25)}{0.69}\, D_{t-1}\Delta mii_{t-1} \qquad (6.3.1.1)$$

$$+\underset{(0.02)}{0.002}\, a_{t-1} + \underset{(0.05)}{0.04}\, D_{t-1} mii_{t-1} - \underset{(0.12)}{0.04}\, D_{t-1}(pa - pak)_{t-1}$$

$$+\underset{(0.02)}{0.02}\, S_{t-1}k_{t-1} - \underset{(0.03)}{0.04}\, DUM1999(1)_t - \underset{(0.03)}{0.01}\, DUM2002(1)_t$$

$$-\underset{(0.17)}{0.98}\, D_t \Delta pa_t - \underset{(0.12)}{0.08}\, D_{t-1}pa_{t-1} - \underset{(0.02)}{0.10}\, DUM(1)_t - \underset{(0.01)}{0.13}\, DUM(2)_t$$

$$-\underset{(0.01)}{0.18}\, DUM(3)_t + \underset{(0.06)}{0.15}\, I{:}\,2008(2)_t$$

Method: OLS 1980(1) – 2010(4) $R^2 = 0.78$ F(15,108) = 25.73 [0.000] σ = 0.05

RSS = 0.30 for 16 parameters and 124 observations

Residual misspecification tests:			
AR 1-5	F(5,103)	=	0.96 [0.44]
ARCH 1-4	F(4,116)	=	0.38 [0.82]
Normality	$\chi^2(2)$	=	0.16 [0.92]
Hetero	F(22,100)	=	0.91 [0.58]
Hetero-X	F(46,76)	=	0.88 [0.67]
RESET23	F(2,106)	=	0.51 [0.60]

Significance of euro-dummy variables:			
$DUM1999(1)_t$	t-value	=	- 1.45
$DUM2002(1)_t$	t-value	=	- 0.49

Tests for restrictions of price homogeneity:			
$D_t \Delta pa_t$	t-value	=	- 5.68
$D_{t-1} pa_{t-1}$	t-value	=	- 0.68

None of the misspecification tests above are significant. We see that price homogeneity in the short run, but not in the long run, is rejected. Rejection of short-run price homogeneity is again likely to be caused by the fact that economic agents take time to adjust to new information. The recursive graphics presented in Appendix D show some instability of the estimated coefficients throughout the sample period, and also signs of at least one residual outlier.

All of the estimated coefficients, except that of a_{t-1}, have signs consistent with theory. However as $\hat{\rho}$ is now positive and not significantly different from zero, there does not exist an error correction mechanism or a cointegrating relationship. Also, the long-run coefficients would all have the wrong sign. In addition, none of the coefficients are significantly different from zero. This means that the model with indicator functions is a bad fit to the data also in this third production sector, and we thus choose not to derive the long-run equilibrium relation.

6.3.2 Without Indicator Functions

In the case where the amount of exports of machinery products is determined by demand side variables and supply side variables at the same time, the general-to-specific estimation method gives the following error correction model:

$$\Delta a_t = \underset{(1.66)}{-\ 1.73} \underset{(0.06)}{-\ 0.35}\ \Delta a_{t-1} + \underset{(0.10)}{0.25}\ \Delta(pa - pak)_{t-4} \underset{(0.05)}{-\ 0.27}\ a_{t-1} \qquad (6.3.2.1)$$

$$+ \underset{(0.09)}{0.54}\ mii_{t-1} + \underset{(0.11)}{0.03}\ (pa - pak)_{t-1} + \underset{(0.15)}{0.19}\ k_{t-1}$$

$$\underset{(0.02)}{-\ 0.10}\ DUM1999(1)_t \underset{(0.02)}{-\ 0.05}\ DUM2002(1)_t \underset{(0.13)}{-\ 1.08}\ \Delta pa_t$$

$$\underset{(0.11)}{-\ 0.52}\ pa_{t-1} \underset{(0.02)}{-\ 0.08}\ DUM(1)_t \underset{(0.01)}{-\ 0.10}\ DUM(2)_t \underset{(0.01)}{-\ 0.16}\ DUM(3)_t$$

$$\underset{(0.05)}{-\ 0.16}\ I{:}1980(3)_t + \underset{(0.05)}{0.15}\ I{:}2009(3)_t$$

Method: OLS 1980(1) – 2010(4) $R^2 = 0.84$ $F(15,108) = 37.57$ [0.000] $\sigma = 0.05$

RSS = 0.22 for 16 parameters and 124 observations

Residual misspecification tests:

AR 1-5	F(5,103)	=	1.41 [0.23]
ARCH 1-4	F(4,116)	=	0.42 [0.79]
Normality	$\chi^2(2)$	=	3.44 [0.18]
Hetero	F(21,100)	=	0.96 [0.52]
Hetero-X	F(49,72)	=	1.55 [0.04]*
RESET23	F(2,106)	=	0.29 [0.75]

Significance of euro-dummy variables:

$DUM1999(1)_t$	t-value	=	- 4.22
$DUM2002(1)_t$	t-value	=	- 2.32

Tests for restrictions of price homogeneity:

Δpa_t	t-value	=	- 8.18
pa_{t-1}	t-value	=	- 4.86

The misspecification tests show signs of heteroskedasticity in the residuals, as the hetero-X test is significant. We also see that price homogeneity in both the short run and in the long run is rejected. As previously explained, rejection of short-run price homogeneity is likely to be caused by the fact that agents take time to adjust to new information. Rejection of long-run price homogeneity indicates rejection of the long-run equilibrium export relation, but it can also be caused by measurement error. From the recursive graphics presented in Appendix D, we see that most coefficients are stable throughout the sample period, and there are no large residual outliers. We also see that parameter constancy is not rejected by the break point Chow test.

The coefficient of a_{t-1} is significantly lower than zero, meaning that there exists an error correction mechanism and thus a cointegrating relationship. All the other estimated coefficients, with the exception of the coefficient of $(pa - pak)_{t-1}$, in Equation (6.3.2.1) have signs consistent with theory. The coefficients of mii_{t-1}, $DUM1999(1)_t$ and $DUM2002(1)_t$ are all significantly different from zero. The coefficients of k_{t-1} and $(pa - pak)_{t-1}$ are on the other hand not.

Again, the long-run equilibrium export relation is found by dividing through by $-\hat{\rho}$, and this gives:

$$a = 1.98mii + 0.69k - 0.36DUM1999(1) - 0.19DUM2002(1). \qquad (6.3.2.2)$$

The two first coefficients in this long-run equilibrium relation are interpreted as elasticities of export with respect to foreign demand, *MII*, and real capital in production, *K*, respectively. This means that a one per cent increase in foreign demand will lead to a 1.98 per cent increase in the amount of exports; and a one per cent increase in real capital in production will lead to a 0.69 per cent increase in the amount of exports. It is important to note that real capital in production is not significant in this case, but we have nonetheless decided to include it in the long-run equilibrium export relation. Relative prices as an explanatory variable is not included in this equilibrium relation, as the estimations in Equation (6.3.2.1) show a coefficient with sign inconsistent with theory.

The two last coefficients are interpreted as the direct effect on Norwegian exports of machinery products of the introduction of the euro as an accounting currency and as notes and coins respectively. We see that the introduction of the euro as an accounting currency resulted in a decrease in the long-run equilibrium amount of Norwegian exports of 0.36 per cent. The introduction of euro notes and coins resulted in a further decrease of 0.19 per cent. This means that the total direct effect on the equilibrium amount of Norwegian exports of the introduction of the euro was a decrease of (0.36 + 0.19) = 0.55 per cent. This decrease in the amount of Norwegian exports of machinery products was caused by lower transaction costs and the lower risk of exchange rate volatility within the European currency union, which resulted in importing euro area countries substituting away from Norwegian products. The introduction of the euro gave Norwegian exports a disadvantage as compared to competing products from exporting euro area countries. If the euro area is disbanded, and there no longer exists a currency union within the EU, this disadvantage will disappear and the amount of Norwegian exports of machinery products is expected to increase by 0.55 per cent.

7 Conclusions

The purpose of this thesis was to investigate the direct effect on Norwegian exports of a hypothetical disbandment of the euro area. This has been done by looking at what happened to Norwegian exports when the euro was introduced in two steps in 1999 and 2002. An export determination model has been derived from theory, where the amount of exports depends on the explanatory variables foreign demand, relative prices and real capital in production. We have investigated two versions of this export determination model, one in which the amount of exports in each time period depends either only on demand side variables or only on supply side variables; and one whereby the amount of exports in each time period depends both on demand side variables and supply side variables at the same time. Step-dummy variables for the introduction of the euro were included in the model in order to analyse the isolated euro effect on Norwegian exports. The hypothesis was that the introduction of the euro led to a decrease in Norwegian exports because of substitution away from Norwegian products as a result of the lower transaction costs and the lower risk of exchange rate volatility within the currency union.

The econometric analysis shows that the version with indicator functions, i.e. where demand in each period depends either only on demand side variables or only on supply side variables, is not a good fit to the data, as it for all three production sectors gave estimated coefficients with signs inconsistent with theory.

Conversely, the version without indicator functions, i.e. where demand in each period depends on both demand side variables and supply side variables at the same time, mostly produced estimated coefficients with signs consistent with theory. This version of the export determination model also performs reasonably well when confronted with a number of tests for misspecification. In addition, the recursive graphics show that most of the estimated coefficients are constant throughout the sample period in all three production sectors.

Price homogeneity in the short run is rejected for various industry products and machinery products. This is likely to be caused by the fact that economic agents take time to adjust to new information because of binding contracts and asymmetric information. For machinery products, price homogeneity in the long run is also rejected. This indicates a rejection of the long-run equilibrium specification of the model. It can however also be caused by measurement error. For metals, price homogeneity neither in the long run nor in the short run is rejected.

For all three sectors, estimations show a negative direct effect on exports as a result of the introduction of the euro as an accounting currency in 1999. Furthermore, the empirical analysis shows an increase of exports of metals in 2002 when euro coins and notes came into circulation; this is inconsistent with the hypothesis. This positive effect, in absolute value, is smaller than the negative effect of the introduction of the euro as an accounting currency in 1999. Hence, the overall effect was still negative, but it is however unlikely to be significantly different from zero. For the two other product groups, various industry products and machinery products, the effects were negative both in 1999 and 2002. This leads to the conclusion that if the euro area is disbanded, the direct effect on Norwegian exports of various industry products and of machinery products is expected to be positive, whereas the direct effect on the amount of exports of Norwegian metals is likely to not be significantly different from zero.

It is important to note that the expected positive direct effect on Norwegian exports of various industry products and machinery products, as a result of a disbandment of the euro area, is likely to be outweighed by negative effects that have not been investigated in this thesis. Such negative effects might be a decrease in foreign demand, MII, or in competing exporting countries' prices, PAK, as a result of general economic recession in Europe. There might also be negative effects that are not accounted for by any of the explanatory variables in the model. It is however difficult to say anything specific about the magnitude of these effects without any further investigations. The focus in this thesis has nonetheless been on the direct effect on Norwegian exports of a disbandment of the euro area, and we have found that the expected effect is positive for two of the three production sectors in question.

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Appendix A: Data definitions and Sources

A — Norwegian exports of relevant product in constant prices. Source: Statistics Norway.

K — The stock of capital in the relevant sector in Norwegian industry. Source: Statistics Norway.

KAP — Index for capital utilization in the relevant sector in Norwegian industry. Calculated using the Modified Wharton-Method (Cappelen and von der Fehr, 1986). Source Statistics Norway.

MII — Weighted volume index for total commodity exports demand faced by Norwegian manufacturing. Source Statistics Norway.

PA — Price index for Norwegian exports. Source: Statistics Norway.

PAK — Price index for

PMET — Price index for metals (measured in Norwegian kroner. Source: The International Monetary Fund (IMF).

25 — Code for various industry products (diverse industriprodukter).

43, 30 — Code for metals (metaller).

46, 45 — Code for machinery products (vekstedsprodukter).

DUM1999(1) — Step-dummy variable used to account for isolated euro effect when the euro was introduced as an accounting currency. Equals one from the first quarter of 1999 and zero before that.

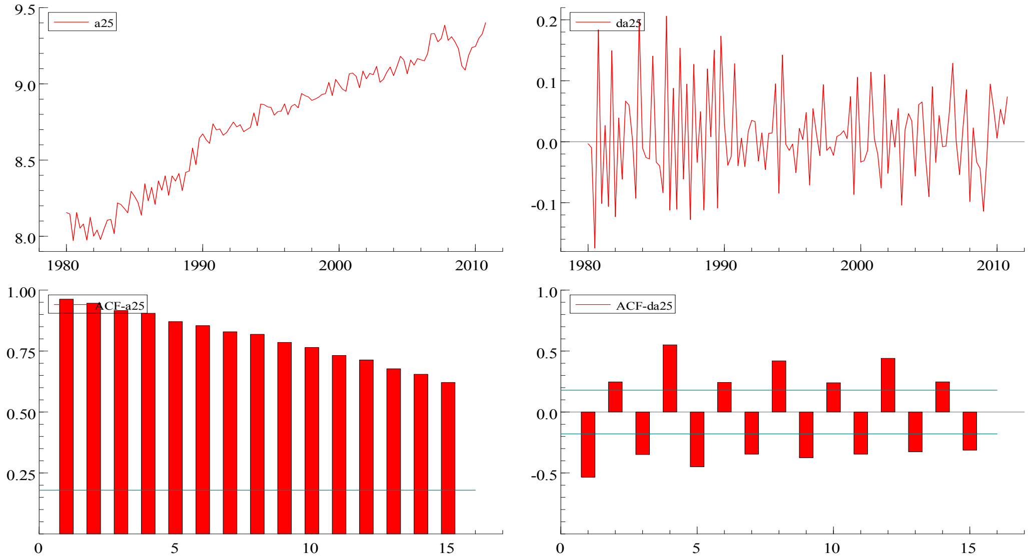
DUM2002(1) — Step-dummy variable used to account for isolated euro effect when the euro coins and notes were introduced. Equals one from the first quarter of 2002 and zero before that.

I:yyyy(q) — Impulse-dummy variable used to account for an outlier in the equation. Equals one in year yyyy, quarter q, 0 otherwise.

DUM(q)	Seasonal dummy variable for quarter q, equals 1 in quarter q, 0 otherwise, i=1,2,3.

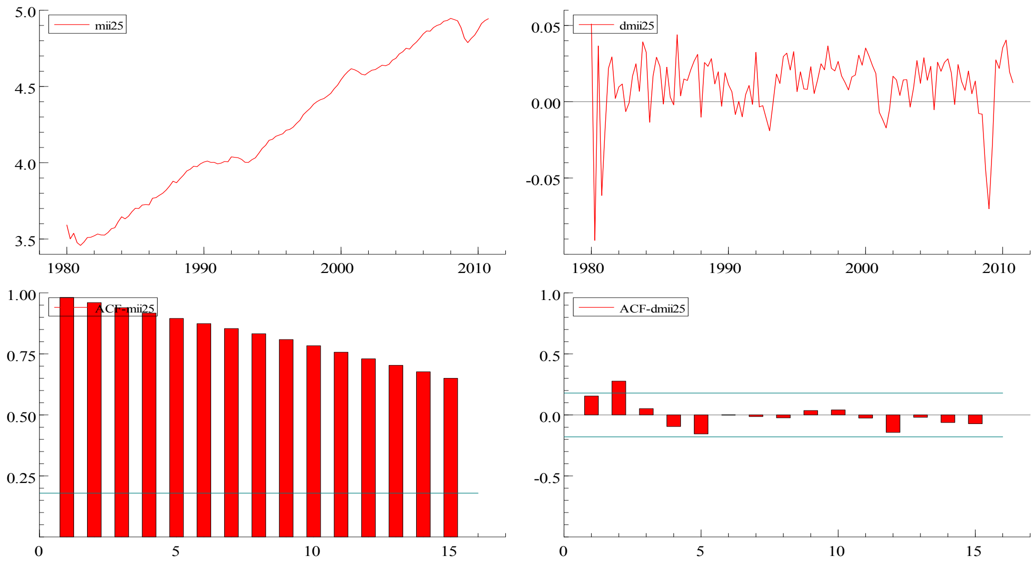
Appendix B: Time series used in the empirical modelling in chapter 6 and tests for unit roots

Exports, Various Industry Products



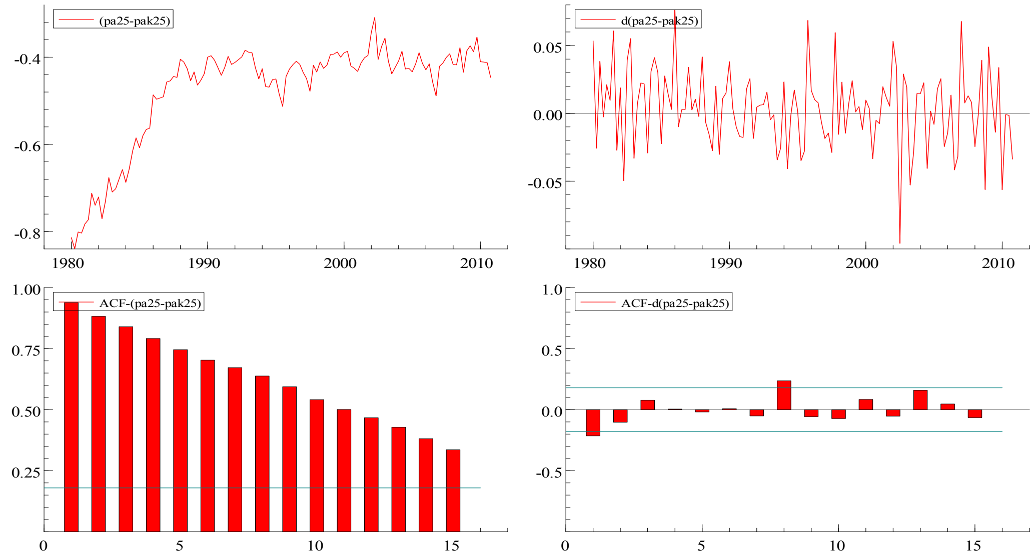
Variable	Lags	Period	Trend	Seasonal	DW	t-adf	Critical value
a25	5	1980(1)-2010(4)	Yes	Yes	1.981	-2.95	-3.446
Δa25	4	1980(1)-2010(4)	No	Yes	1.939	-4.994	-2.885

Foreign Demand, Various Industry Products



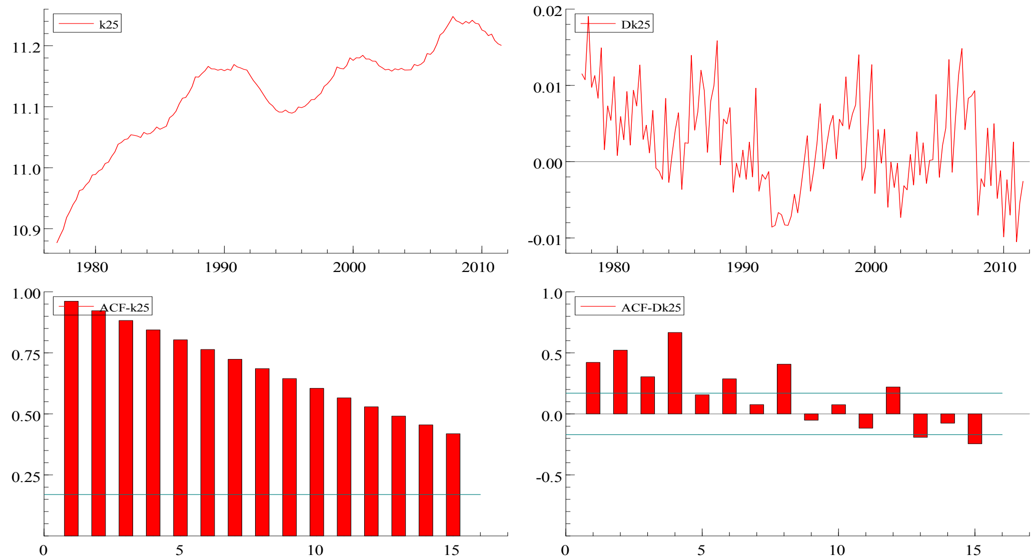
Variable	Lags	Period	Trend	Seasonal	DW	t-adf	Critical value
mii25	5	1980(1)-2010(4)	Yes	No	2.016	-2.826	-3.446
Δmii25	4	1980(1)-2010(4)	No	No	2.072	-5.898	-2.885

Relative Prices, Various Industry Products



Variable	Lags	Period	Trend	Seasonal	DW	t-adf	Critical value
(pa25-pak25)[12]	2	1980(1)-2010(4)	No	No	2.092	-3.612	-2.885

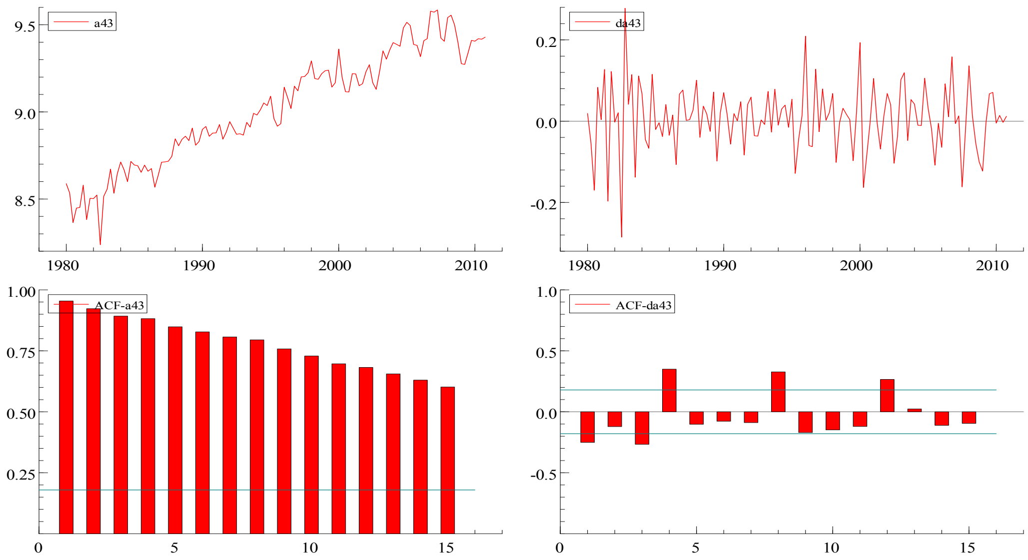
Real Capital, Various Industry Products



Variable	Lags	Period	Trend	Seasonal	DW	t-adf	Critical value
k25	3	1980(1)-2010(4)	Yes	Yes	2.094	-2.913	-3.446
Δk25	2	1980(1)-2010(4)	No	Yes	2.054	-2.974	-2.885

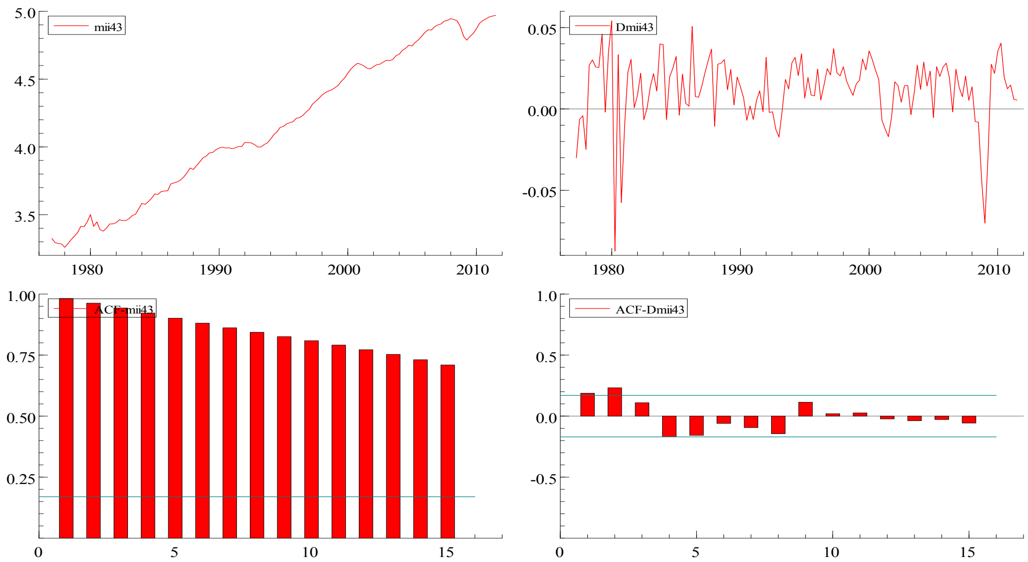
[12] Even though the test indicates that the variable relative prices for various industry products is I(0), we will treat it as I(1) in the empirical analysis.

<u>Exports, Metals</u>



Variable	Lags	Period	Trend	Seasonal	DW	t-adf	Critical value
a43[13]	1	1980(1)-2010(4)	Yes	Yes	2.125	-5.04	-3.446

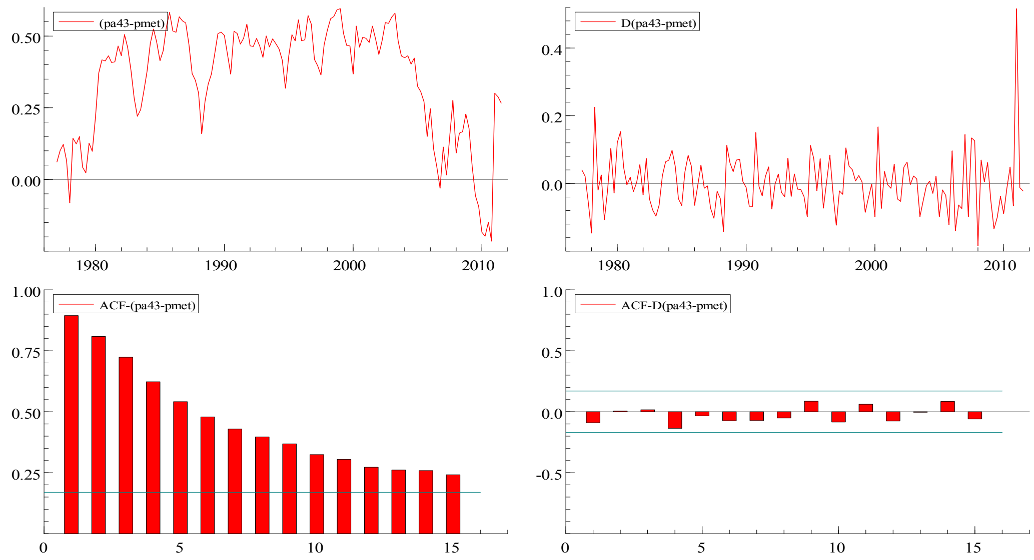
<u>Foreign Demand, Metals</u>



Variable	Lags	Period	Trend	Seasonal	DW	t-adf	Critical value
mii43	3	1980(1)-2010(4)	Yes	No	2.058	-3.081	-3.446
Δmii43	2	1980(1)-2010(4)	No	No	2.008	-5.787	-2.885

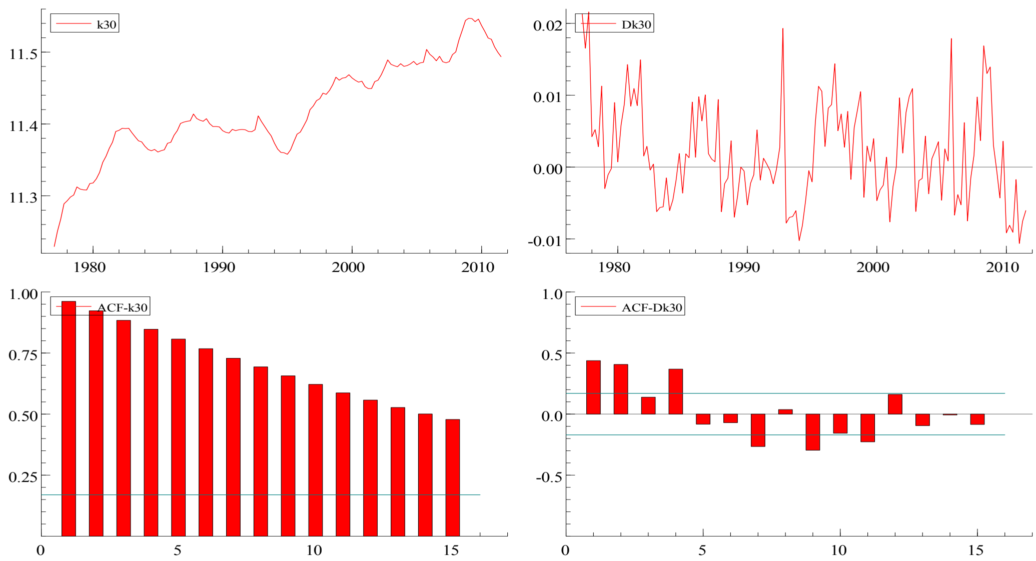
[13] Even though the test indicates that export of metals is I(0), we will treat it as an I(1) variable in the empirical analysis.

Relative Prices, Metals



Variable	Lags	Period	Trend	Seasonal	DW	t-adf	Critical value
(pa43-pmet)	1	1980(1)-2010(4)	Yes	No	1.969	-2.31	-3.446
Δ(pa43-pmet)	0	1980(1)-2010(4)	No	No	2.959	-11.26	-2.885

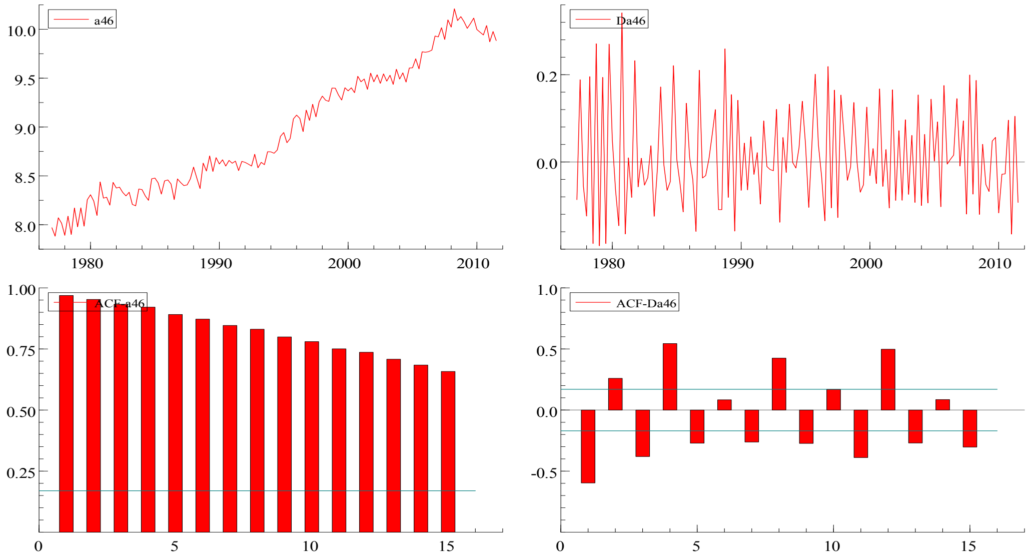
Real Capital, Metals



Variable	Lags	Period	Trend	Seasonal	DW	t-adf	Critical value
k30[14]	2	1980(1)-2010(4)	Yes	Yes	2.278	-3.561	-3.446

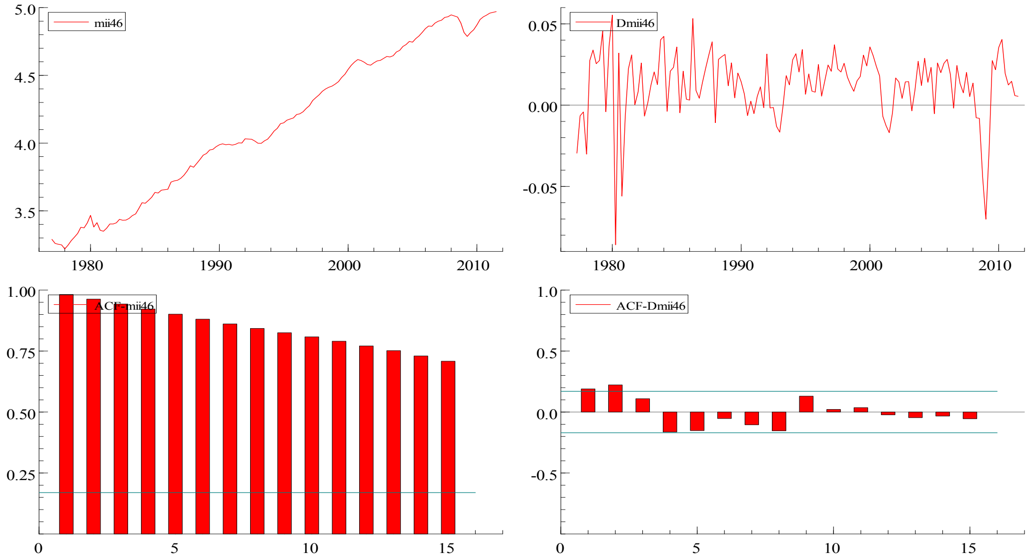
[14] Even though the test indicates that the real capital in production of metals is I(0), we will treat it as an I(1) variable in the empirical analysis.

Exports, Machinery Products



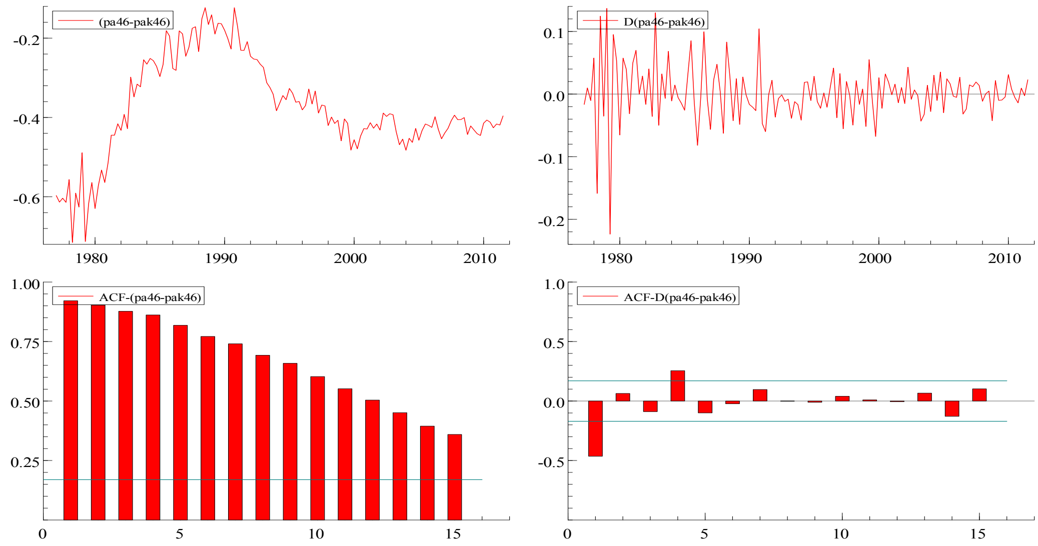
Variable	Lags	Period	Trend	Seasonal	DW	t-adf	Critical value
a46	6	1980(1)-2010(4)	Yes	Yes	2.085	-2.448	-3.446
Δa46	5	1980(1)-2010(4)	No	Yes	2.046	-4.097	-2.885

Foreign Demand, Machinery Products



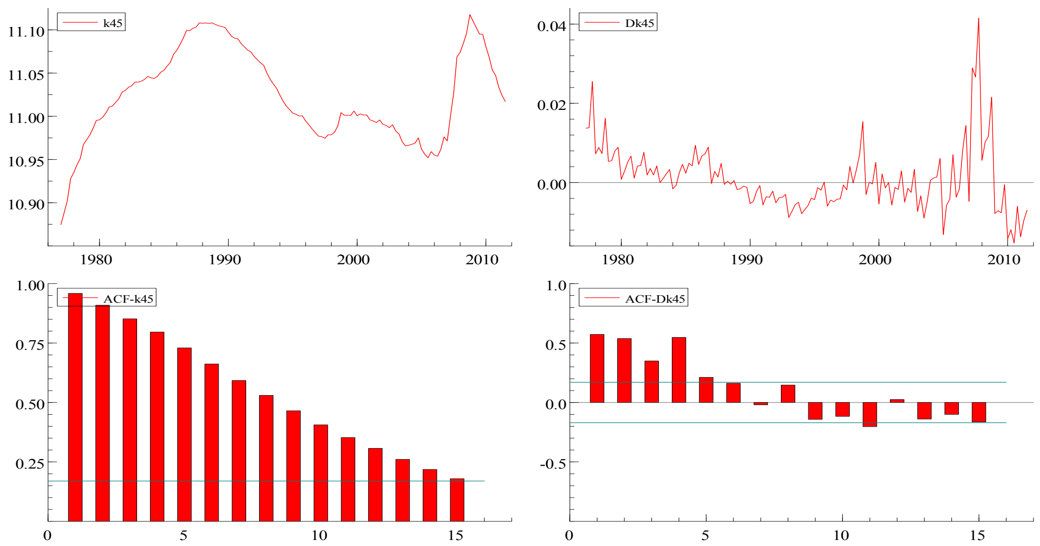
Variable	Lags	Period	Trend	Seasonal	DW	t-adf	Critical value
mii46	3	1980(1)-2010(4)	Yes	No	2.052	-2.905	-3.446
Δmii46	2	1980(1)-2010(4)	No	No	2.008	-5.815	-2.885

Relative Prices, Machinery Products



Variable	Lags	Period	Trend	Seasonal	DW	t-adf	Critical value
(pa46-pak46)	10	1980(1)-2010(4)	Yes	Yes	2.004	-3.386	-3.446
Δ(pa46-pak46)	9	1980(1)-2010(4)	No	Yes	1.99	-2.592	-2.885
Δ^2(pa46-pak46)[15]	8	1980(1)-2010(4)	No	Yes	2.013	-6.78	-2.885

Real Capital, Machinery Products



Variable	Lags	Period	Trend	Seasonal	DW	t-adf	Critical value
k45[16]	5	1980(1)-2010(4)	No	Yes	1.875	-3.186	-2.885

[15] Even though the test indicates that relative prices for machinery products is I(2), we will treat it as an I(1) variable in the empirical analysis.
[16] Even though the test indicates that the real capital in the productions of Norwegian machinery products is I(0), we will treat it as an I(1) variable in the empirical analysis.

Appendix C: Method of Estimation in OxMetrics 6.20

When estimating the general version of the error correction model with five lags, the following variables were originally set as fixed in order to force them to be part of the estimated model:

- Constant term
- a_{t-1}
- $D_{t-1}mii_{t-1}$ when indicator functions are included, and mii_{t-1} when there are no indicator functions
- $D_{t-1}(pa - pak)_{t-1}$ when indicator functions are included, and $(pa - pak)_{t-1}$ when there are no indicator functions
- $S_{t-1}k_{t-1}$ when indicator functions are included, and k_{t-1} when there are no indicator functions
- $D_t\Delta pa_t$ when indicator functions are included, and Δpa_t when there are no indicator functions
- $D_{t-1}pa_{t-1}$ when indicator functions are included, and pa_{t-1} when there are no indicator functions
- $DUM1999(1)_t$
- $DUM2002(1)_t$

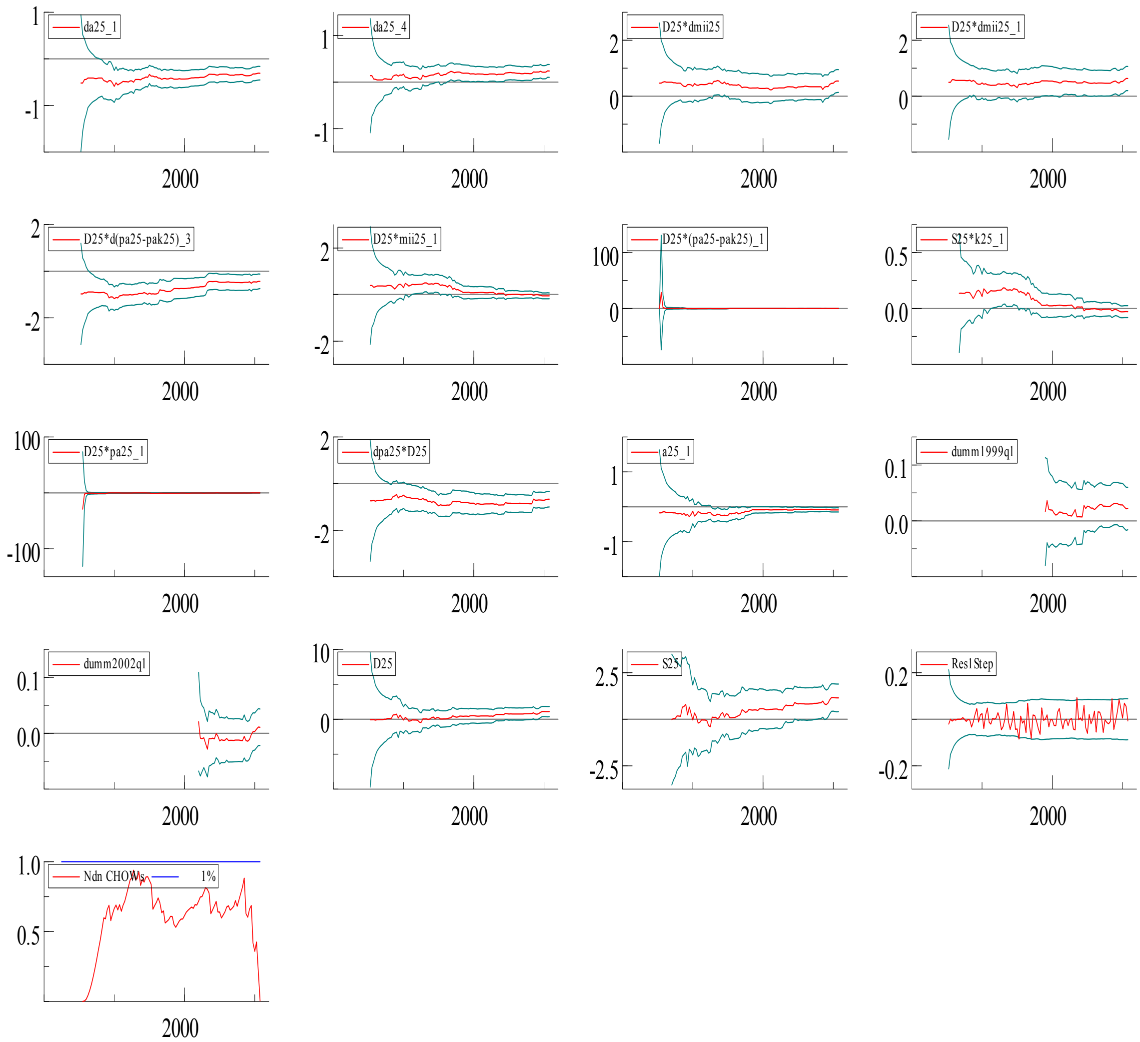
We have included seasonal dummies, $DUM(1)_t$, $DUM(2)_t$ and $DUM(3)_t$ (but not set them as fixed), in order to account for seasonal variation in the data.

In the model settings and the Autometrics options, automatic model selection, pre-search lag reduction and dummy saturation with small target size as outlier detection, are chosen.

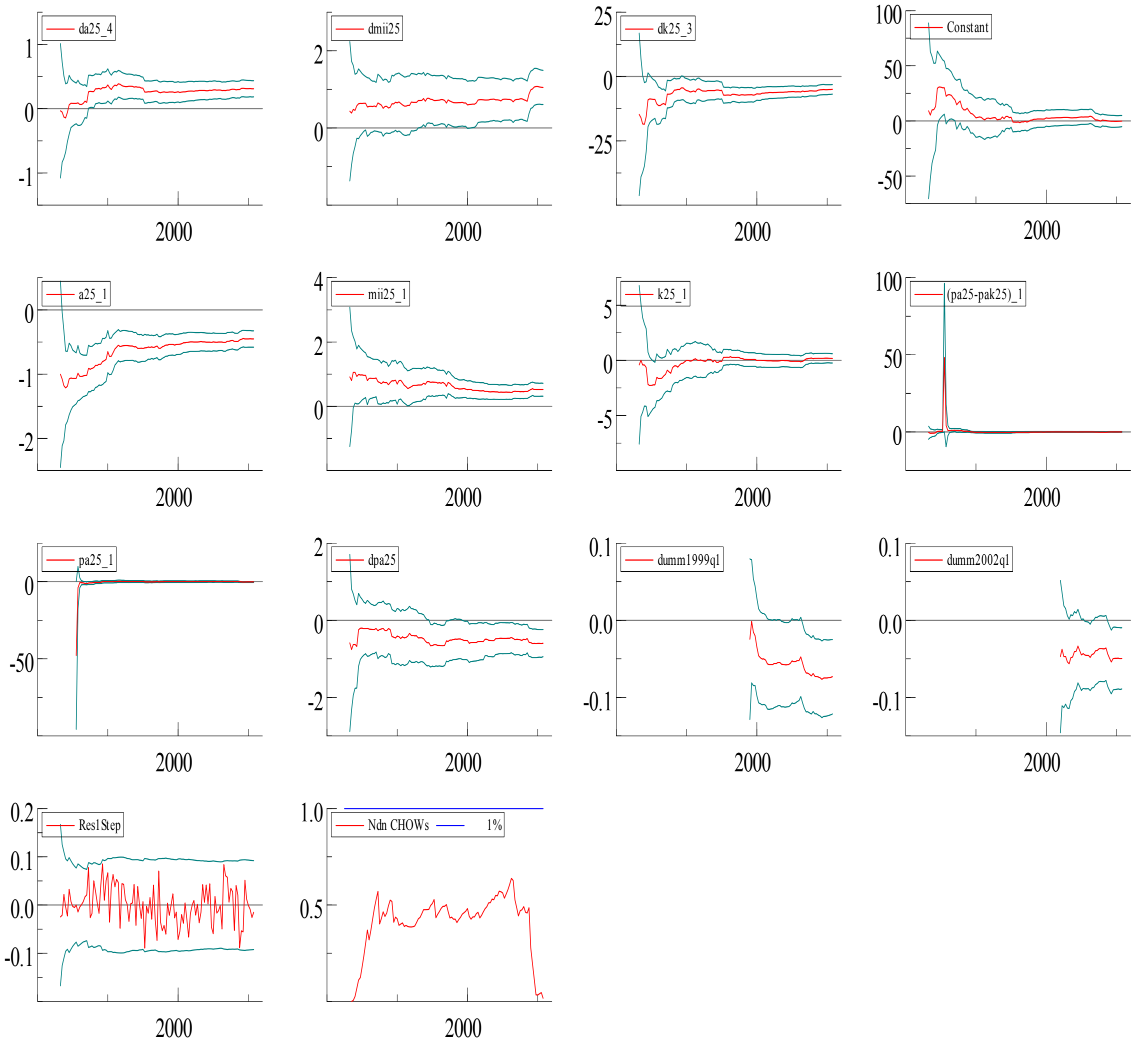
The estimation sample is 1980(1) – 2010(4). Recursive estimation with initialisation 10 and default standard errors are chosen.

Appendix D: Recursive least squares graphical constancy statistics. d = Δ.

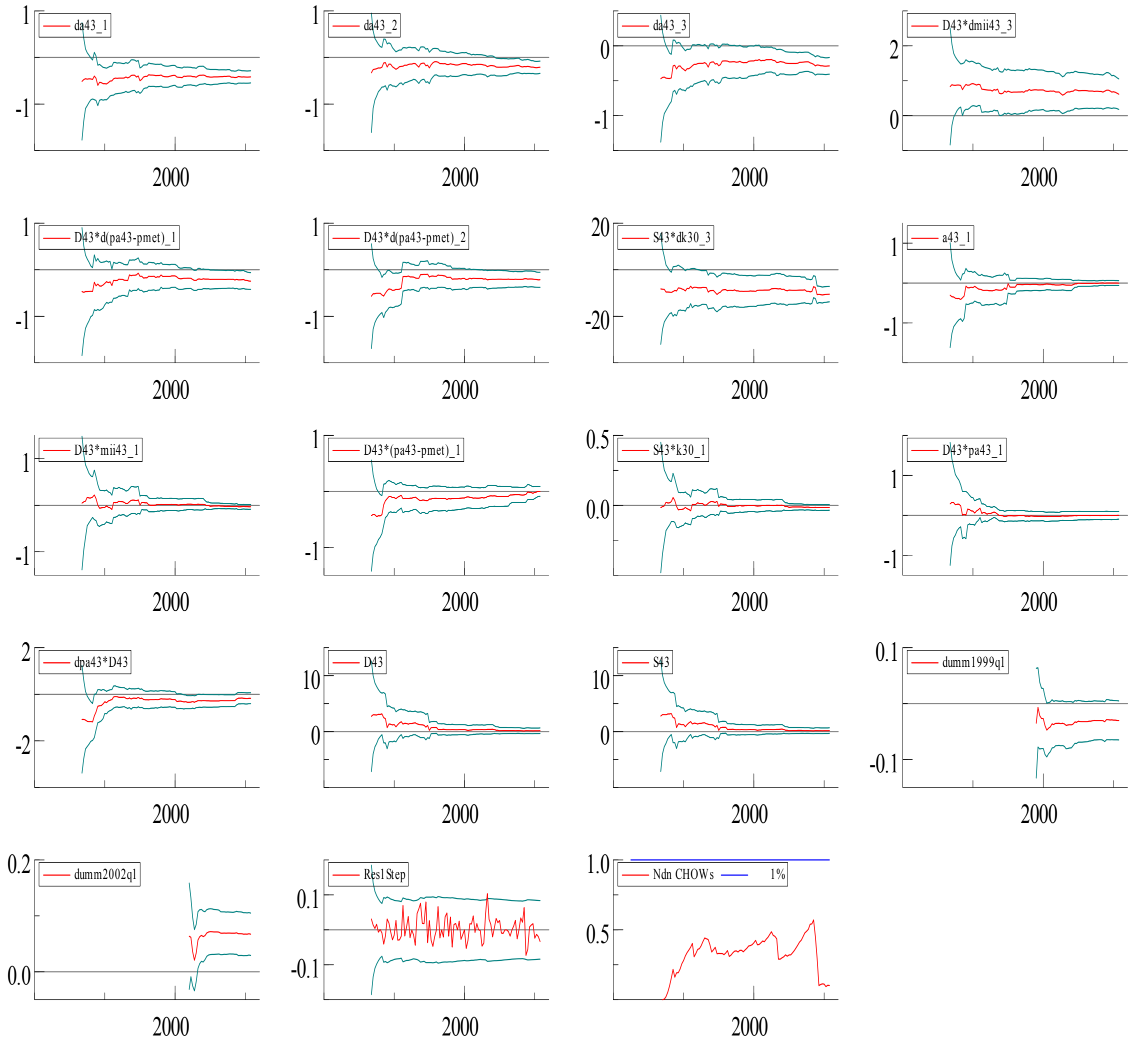
Various Industry Products with Indicator Functions



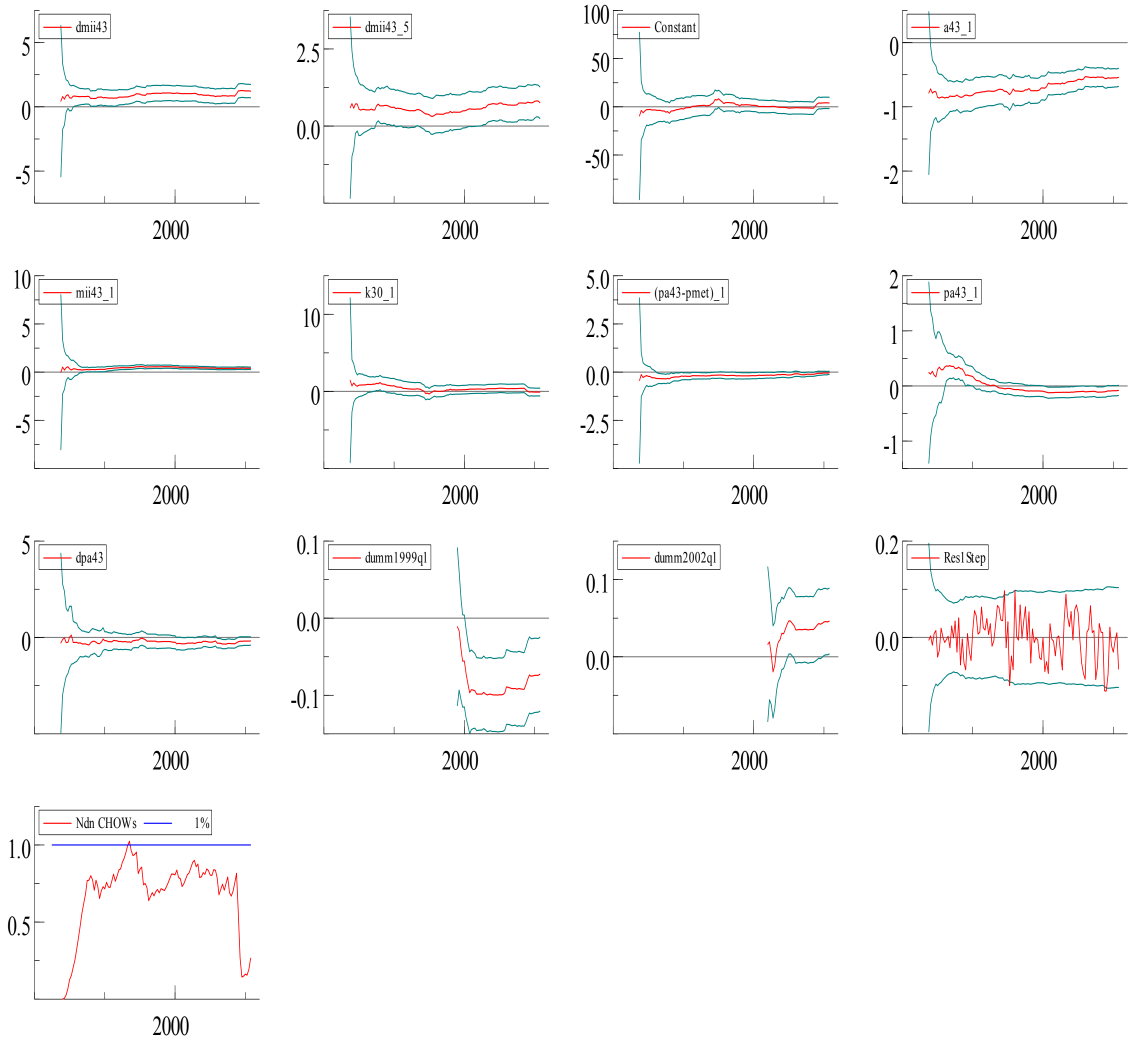
Various Industry Products without Indicator Functions



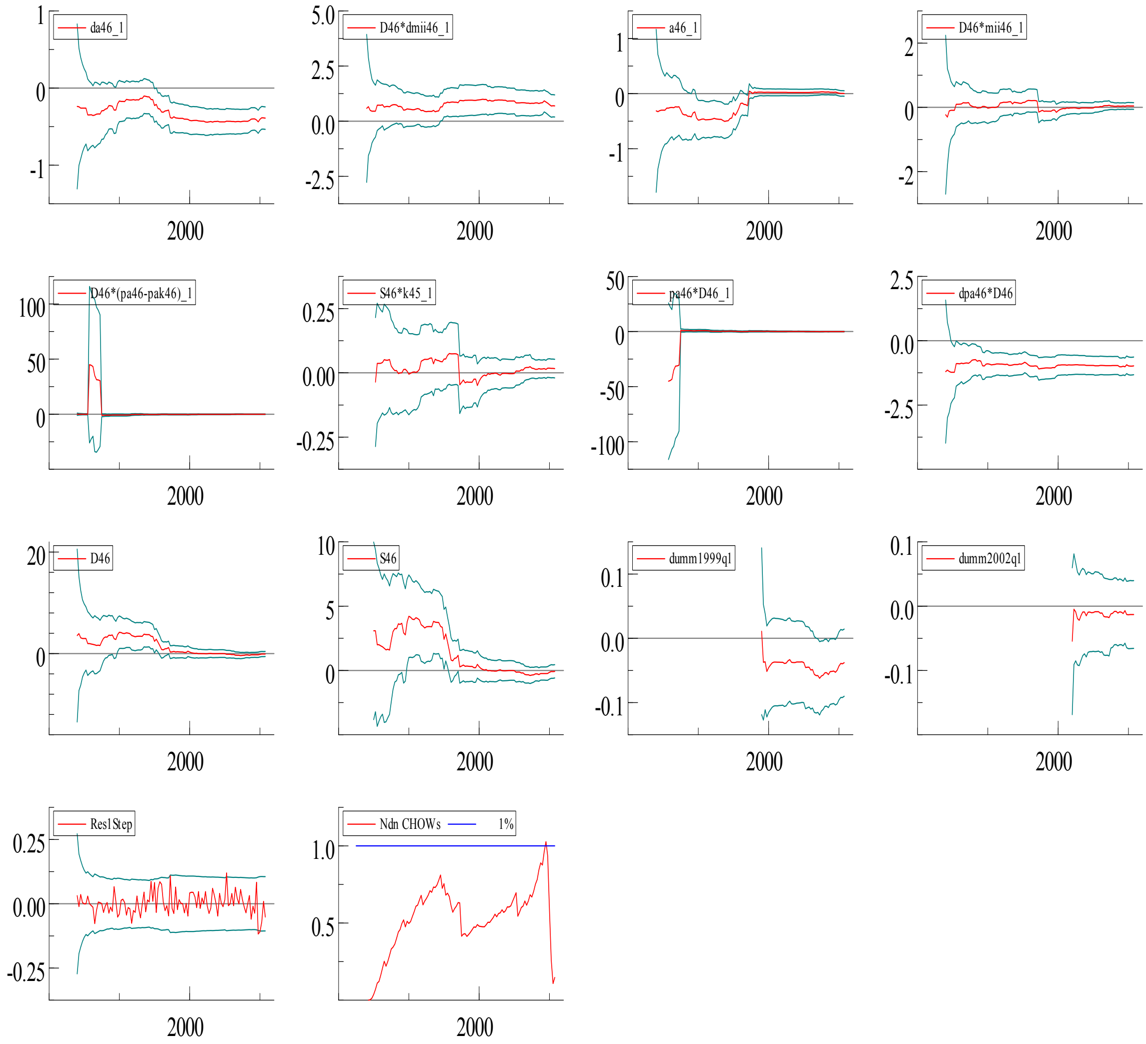
<u>Metals with Indicator Functions</u>



Metals without Indicator Functions



<u>Machinery Products with Indicator Functions</u>



<u>Machinery Products without Indicator Functions</u>