



M.Sc. Thesis

Economics

PPP Mean-Reversion Estimation for Iceland

A Unit-Root & Single-Equation Cointegration Approach

Using New Long-Run Time Series

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Supervisor: Dr. Gylfi Magnússon

Faculty of Economics

February 2014



HÁSKÓLI ÍSLANDS

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by

Páll Þórarinn Björnsson

in Partial Fulfilment of the Requirements for the Degree of

Master of Science in Economics

Thesis Supervisor: Dr. Gylfi Magnússon

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This dissertation equals 30 ECTS credits towards partial fulfilment for the M.Sc. degree in Economics at the Faculty of Economics.

School of Social Science, University of Iceland

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Preface

This dissertation equals 30 ECTS credits towards partial fulfilment of the requirements for the Master of Science degree (M.Sc.) in Economics, at the University of Iceland. I would like to express my utmost gratitude to the thesis supervisor, Dr. Gylfi Magnússon, for his professional advice and guidance, during the writing of this thesis.

Abstract

This study examines empirical evidence regarding long-run relative purchasing power parity (PPP) convergence for Iceland. The aim is to examine whether the Icelandic króna's fluctuating exchange rate exhibits a tendency towards mean-reversion; that is, to determine if an equilibrium real exchange rate exists for the ISK. Long-run trade-weighted nominal and real effective exchange rate indices are constructed, spanning a 117-year period of the ISK's history. Annual and monthly data are used to construct the indices. The historical exchange rates are calculated as geometrically weighted chain indices with current trade weights based on Iceland's foreign trade in goods. The consumer price index (CPI) is used for deflation. Data are based on 13 to 15 of Iceland's largest trading partners, which accounted for at least 64 per cent of Iceland's total foreign trade in goods each year, during the period in question.

Empirical estimations are applied to the new time-series. Unit-root and single-equation cointegration tests are performed for stationarity estimation. Mean-reversion from PPP deviation is analysed via autoregressive models, with half-life calculations based on ordinary least squares (OLS) parameter estimates. Empirical estimations are applied to the period as a whole, as well as individual estimations for two sub-periods, due to a structural break in the series. Separate estimations are also carried out for post-1988 period, using monthly data.

The results are consistent with results from similar studies on purchasing power parity. Evidence supporting relative PPP convergence is found for all but one of the periods, (post-1988), where results from unit-root and cointegration tests contradict, indicating failure of PPP convergence for the period. Half-life estimates, are around four years for the period as a whole. The most rapid mean reversion appears during the inter-war and post-1981 periods. The inter-war period also shows the least volatility in the real exchange rate of the ISK.

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1 Introduction

In the modern world, currency exchange rate developments are a fundamental part of international economics. Exchange rates can have a substantial effect on external trade and other financial transactions between countries. The more dependent a country is on external trade, the more currency fluctuations can affect its economy.

Unpredictable exchange rate volatility can sometimes have adverse effects on financial stability. The fluctuating exchange rate of the Icelandic króna have played a major role in the history of the Icelandic economy. Iceland is a small, open economy that relies on external trade, with exports and imports averaging around 30 per cent of GDP during the past century, *cf.* Appendix III, Figure 1.

The aim of this study is to examine whether the ISK's fluctuating exchange rate exhibits a tendency towards mean-reversion; *i.e.*, to determine whether an equilibrium real exchange rate exists for the ISK in the long run.

Long-run trade-weighted nominal and real effective exchange rate indices are constructed for the ISK from 1895 to 2012, or almost from its introduction as a currency¹. Annual data are used for the period between 1895 and 1988 for the construction of the indices. For the period from 1988 to 2012 monthly data are used. The historical exchange rates are constructed as geometrically weighted chain indices with current trade weights based on Iceland's foreign trade in goods. The consumer price index (CPI) is used for deflation. Annual data are based on 13 of Iceland's largest trading partners, which accounted for at least 70 per cent of Iceland's total foreign trade in goods each year, during the period. For the monthly data, two more countries are added to the dataset, for a total of 15 trading partners which accounted for at least 64 per cent of Iceland's total foreign trade in goods each month, during the period.

Empirical estimations are applied to the new time series. Unit-root and single-equation cointegration tests are performed for stationarity estimation. The mean reversion from PPP deviation is analysed via autoregressive models, with half-life calculations based on ordinary least squares (OLS) parameter estimates. Empirical estimations are applied to the period as a whole, as well as individual estimations for two sub-periods, that emerged after a structural-break estimation revealed a break-point at 1960. Separate estimations are also carried out for the post-1988 period, using monthly data.

The results are consistent with similar PPP studies. Evidence supporting relative

¹ The first 10 years, between 1885 and 1895, could not be included due to data shortage.

PPP convergence is found for all but one of the periods (post-1988), where unit-root and cointegration test results contradict, indicating a failure of PPP convergence. Half-life estimates are around four years for the period as a whole. The most rapid mean reversion appears during the inter-war and post-1981 periods. The inter-war period also shows the least amount of volatility in the real exchange rate of the ISK.

The paper is structured as follows: Section 2 contains a brief overview of the purchasing power parity theory. Description of the data set and methodology for the calculations of the historical indices are found in Section 3. Section 4 contains an overview of the empirical methodology for PPP estimations, followed by empirical findings in Section 5. The final section contains the conclusions and a brief discussion of the scope for further research².

² Detailed data descriptions, figures, tables, and regression outputs are included in accompanying appendices.

2 Purchasing Power Parity (PPP)

Purchasing power parity (PPP) is one of the fundamental theories in international economics. The theory postulates that currency exchange rates adjust over time to offset divergent movements in national price levels. Persistence of real exchange rates can be used for validation of the purchasing power parity theory, *e.g.* by estimation of the real exchange rate mean-reversion behaviour. Despite its simplicity, the theory is widely debated in the literature. The general consensus seems to be that the theory holds in the long run, although short-run parity convergence is generally not accepted (Kulkarni, 1990-1991).

2.1 Law of One Price

Although the term purchasing power parity was originally coined by Gustav Cassel in 1922, the idea behind the theory has been around for much longer and exists today in a number of variations. The Big Mac index, published by *The Economist*, is an example of a well-known variation of PPP. It shares the same fundamental premise as PPP, the so-called law of one price (LOOP). According to LOOP, due to arbitrage, any price difference in an internationally trade-able good between countries should not exist, at least not in the long run. The cheaper good would simply be exported and transported to the more expensive location until equilibrium in price and quantity was reached between the two locations³. LOOP is given by:

$$\begin{aligned}p_t(i) &= p_t^*(i) + v_t \\v_t &= p_t(i) - p_t^*(i) \\p_t(i) - v_t &= p_t^*(i)\end{aligned}$$

where $p_t(i)$ is the *log* of the time- t domestic-currency price of good i , $p_t^*(i)$ is the analogous foreign-currency price, and v_t is the *log* of the time- t domestic-currency price of foreign exchange.

³ Internationally integrated and open markets are necessary for LOOP to hold.

2.2 Absolute PPP

PPP and LOOP are essentially two sides of the same coin. The main difference between the two is that PPP uses a basket of goods for comparison instead of just one individual item. If LOOP holds for every individual item, an assumption can be made that for any identical variation of baskets of goods, LOOP should also hold. Absolute PPP, or strong PPP, assumes that the price of identical baskets of goods should be identical between two separate economies. Absolute PPP is given by:

$$\begin{aligned}p_t(CPI) &= p_t^*(CPI) + v_t \\v_t &= p_t(CPI) - p_t^*(CPI) \\p_t(CPI) - v_t &= p_t^*(CPI)\end{aligned}$$

2.3 Relative PPP

Due to strict conditions of the absolute version, empirical testing focuses rather on the relative form of PPP, also known as weak PPP. Relative PPP uses relative (percentage) change in exchange rates over a given period. The difference in inflation rates during that same period should offset the difference in price between two economies over the same period. Nominal exchange rates should be equal to the ratio of aggregate price levels between the two economies, so that a currency unit of one country will have the same purchasing power in a foreign country (Taylor, 2004). Relative PPP is given by:

$$\begin{aligned}\Delta p_t(CPI) &= \Delta p_t^*(CPI) + \Delta v_t \\ \Delta v_t &= \Delta p_t(CPI) - \Delta p_t^*(CPI) \\ \Delta p_t(CPI) - \Delta v_t &= \Delta p_t^*(CPI)\end{aligned}$$

From the relative version of purchasing power parity, a simple equation can be derived and transformed for empirical testing of the theory (Taylor, 1996).

In reality many things stand in the way of PPP convergence. Essentially anything that increases marginal costs, can drive a wedge between buyers and sellers and lead to failure of PPP convergence; *e.g.*, transaction costs, transportation costs, import restrictions, tariffs, *etc.*

PPP convergence can be a relatively slow process. It can prove challenging to empirically distinguish a slow reverting stationary real exchange rate, from a random walk. Noise from volatile exchange rates can mask slow convergence toward an ex-

isting equilibrium. Estimating longer time series that incorporate different exchange rate policies, *e.g.* combining fixed and floating exchange rate periods in one continuous series can increase the accuracy of empirical testing. Using a multi-country environment for estimation is also important for increased accuracy.

A drawback of the purchasing power parity theory is the assumption that trading relations are the sole contributing factor to price and exchange rate developments. This is an understatement as many other factors influence exchange rate dynamics. The interest rate spread is thought to be one of those influencing factors. The uncovered interest rate parity theory (UIP) relies on the premise that the interest rate difference between two financial assets should be offset by the expected rate of change in the exchange rate between two currencies over the period to maturity (Beirne, 2010).

A wealth of literature concerning deviations from purchasing power parity exists. Rogoff (1996) writes about the reluctance of real exchange rate mean-reversion when estimated⁴. He points out that storage costs, labour costs, transportation costs, tariffs and non-tradable components of tradable goods, drive a wedge between domestic and foreign prices.

The Balassa-Samuelson effect, one of the driving factors of real currency exchange rates, could be an underestimated culprit behind the failure of PPP convergence⁵. Government spending could also be a contributing factor, leading to PPP failure, as the non-tradable sector is usually more influenced by government spending than the tradable sector.

Possible methodology errors in PPP estimation might lead to non-stationary and slow mean-reversion estimations. Temporal aggregation and linear specification are underestimated factors contributing to slow mean reversion estimates of real exchange rates, according to Taylor (2000). Linear restrictions force shocks to adjust back in a linear fashion, and therefore cannot account for mean reversion adjustments, which, might damp out at a faster rate than it began. Half-life estimation using aggregated data, whether of annual, quarterly or monthly frequency, usually overestimates half-life times, because high-frequency adjustment processes can never be evaluated by low-frequency data; the greater the aggregation, the greater the bias. Combining the two errors can exacerbate the problem even further.

Finally, the speed of reversion to parity is likely to depend on goods-specific

⁴ Rogoff's (1996) purchasing power parity puzzle is as follows: *"How can one reconcile the enormous short-term volatility of real exchange rates with the extremely slow rate at which shocks appear to damp out?"*.

⁵ The Balassa-Samuelsson effect states that measured in the same unit, price levels in high income countries are higher than those in low income countries, due to differences in productivity in the tradable and non-tradable sectors. The non-tradable sector is more affected than the tradable sector, consequently the Balassa-Samuelsson effect is more pronounced in the CPI than WPI (Rogoff, 1996).

characteristics, and is therefore not homogeneous across sectors. Failure to account for cross-sectoral heterogeneity in the dynamic properties of the typical price index components affects the estimated half-lives (Imbs *et al.*, 2002).

3 Historical ISK Exchange Rate

The Central Bank of Iceland is responsible for official exchange rate calculations for the ISK. The bank bases calculations of the nominal exchange rate on predetermined weights. The composition of Iceland's external trade from the previous year determines weight composition. Nominal exchange rate movements reflect appreciation/depreciation *vis-à-vis* the currencies of the major trading nations that are included in the calculations.

Two separate real exchange rates for the króna are published by the Central Bank. One is based on relative consumer prices and the other is based on relative unit labour costs. An increase in the real exchange rate describes a real appreciation of the ISK relative to its trading partners. Real exchange rates are essentially indicators of developments in a country's international competitiveness (Central Bank of Iceland, 2013).

Annual real exchange rates for the ISK are available from the Central bank dating back to 1980. Monthly data are available from 1985. No official real exchange rate data are available prior to 1980. In an article published in 1985 the real ISK exchange rate is calculated back to 1914 (Nordal & Tómasson, 1985). Calculations were based on data from three of Iceland's largest trading partners: the US, the UK, and Denmark. No real exchange rate data for the ISK are available for the period before 1914.

To construct historical time-series for PPP analysis, a multi-country environment is needed in order to reflect changes in trade patterns on a current basis. Using data from two countries for estimation, is unlikely to yield an adequate explanation of exchange rate behaviour that is driven by interactions of multiple trading partners (Beirne, 2010).

3.1 The Data Set

For historical exchange rate calculations, annual external trade data for Iceland were compiled for 13 of Iceland's largest trading partners during the period from 1895 to 1988. The trading partners are Denmark, Finland, France, Germany, Italy, Japan, the Netherlands, Norway, Portugal, Spain, Sweden, the UK, and the US. During the period, these countries accounted for at least 70 per cent of total foreign trade

and an average of 87 per cent⁶. Monthly data were compiled from January 1988 through December 2012. In addition to the previous list of trading partners, two more countries are added for the monthly data: Belgium and Switzerland. In all, these countries accounted for at least 64 per cent of Iceland's total external trade, with an average of 83 per cent⁷.

Annual averages of consumer price indices were compiled for the previously listed countries, for the period from 1895 to 1988. Monthly averages were compiled from 1988 through 2012. When available, the consumer price index is replaced by the Harmonized index of consumer prices (HICP)⁸.

Annual averages of bilateral exchange rates of the Icelandic króna versus the currencies of the previously listed countries were compiled for the period from 1895 to 1988. Monthly averages were used for the period between 1988 and 2012. Further data details can be found in the appendices.

The following time-series were constructed:

1. Xc^N : **Nominal effective exchange króna rate.** Annual observations from 1895 to 1988. Monthly observations from 1988m01 through 2012m12. An increase in the nominal index represents an appreciation of the ISK's nominal value versus the currencies of Iceland's main trading partners.
2. Xc^R : **Real effective exchange króna rate.** Annual observations from 1895 to 1988. Monthly observations from 1988m01 through 2012m12. An increase in the real index represents an appreciation of the ISK's real value versus the currencies of Iceland's main trading partners.
3. CPI^I : **Consumer price index for Iceland.** Annual observations from 1895 to 1988. Monthly observations from 1988m01 through 2012m12.
4. CPI^F : **Foreign consumer price index.** Annual observations from 1895 to 1988 and monthly observations from 1988m01 through 2012m12. The index is constructed as geometrically weighted average of Iceland's trading partners.

The consumer price index (CPI), wholesale price index (WPI) and producer price index (PPI) are all commonly used as deflators for PPP estimation. The structure of these price indices can vary across countries, especially in older data (Froot & Rogoff, 1994). Different index structure can distort comparison, causing biased convergence estimations. Other factors including different preferences, traditions, and others, can also affect the index structure in each country, reducing reliability for comparison⁹.

⁶ With an exception during the 1950s, *cf.* Appendix III.

⁷ *Cf.* Appendix III, Figures 3 & 4.

⁸ Initial starting dates of HICP measurements, vary from country to country.

⁹ HICP should eliminate this distortion. *cf.* Appendix I, for details.

The use of WPI or PPI seem to give more accurate results when it comes to PPP estimations. They usually place greater emphasis on tradable goods than the consumer price index, which ordinarily includes substantial amounts of non-tradable goods, as well as being generally more susceptible to effects caused by indirect taxes and subsidies (Taylor & Taylor, 2004). Nonetheless, the consumer price index can serve as a good substitute for the WPI and PPI¹⁰.

3.2 Nominal Effective Exchange Rate Index

In order to calculate the historical real exchange rate for the ISK, historical nominal exchange rates must be constructed first. The nominal exchange rate index is calculated as a geometrically weighted chain index with current weights based on trade statistics for each period since 1895. The index is based on Iceland's total foreign trade in goods¹¹. The weights used for calculating the index are based on the sum of total bilateral imports and exports of goods *vis-à-vis* the major trading partners that are included in this study.

The historical nominal effective króna rate index (Xc^N) is calculated as a geometrically weighted chain index with current weights based on trade statistics for each period. The relative change in the Xc^N index is given by:

$$\frac{Xc_t^N}{Xc_{t-1}^N} = \prod_{i=1}^n \left(\frac{BE_t^i}{BE_{t-1}^i} \right)^{w_{t-1}^i} \quad \text{where} \quad \sum_{i=1}^n w_{t-1}^i = 1$$

where BE_t^i is the bilateral exchange rate between the Icelandic króna and currency i in period t (amount of foreign currency i per Icelandic króna). The index is a geometrically weighted chain where w_{t-1}^i represents the weight for currency i from period $t-1$ to period t . The weight is structured as follows:

$$w_{t-1}^i = \frac{(IP_{t-1}^i + XP_{t-1}^i)}{(\sum IP_{t-1} + \sum XP_{t-1})}$$

w_{t-1}^i is based on the sum of the Icelandic bilateral imports and exports of goods in period $t-1$ *vis-à-vis* country i relative to total Icelandic imports and exports of goods *vis-à-vis* the previously listed countries. Changes in the currencies from 1895 to 1896 are thus weighted with trade weights reflecting the trade pattern in year 1895 *etc.* An increase in the Xc^N describes an overall appreciation of the króna *vis-à-vis* the currencies of the major trading partners (Abildgren, 2004).

¹⁰The consumer price index is the only available deflator for Iceland, covering such a long period.

¹¹Data aggregated, *i.e.* no category distinction.

3.3 Real Effective Exchange Rate Index

The historical real effective króna rate index (Xc^R) is given by:

$$Xc_t^R = \frac{Xc_t^N CPI_t^I}{CPI_t^F}$$

where Xc_t^N is the historical nominal effective króna rate index in period t . CPI_t^I represents the consumer price index for Iceland in period t and CPI_t^F represents the consumer price index for Iceland's trading partners in period t , calculated as a geometrically weighted chain index with current weights based on trade statistics for each period. The relative change in CPI_t^F is given by:

$$\frac{CPI_t^F}{CPI_{t-1}^F} = \prod_{i=1}^n \left(\frac{CPI_t^i}{CPI_{t-1}^i} \right)^{w_{t-1}^i} \quad \text{where} \quad \sum_{i=1}^n w_{t-1}^i = 1$$

where CPI_t^i is the consumer price index for country i in period t and w_{t-1}^i is the weight used for the change in the consumer price index for country i from period $t-1$ to period t , based on the sum of Icelandic bilateral imports and exports of goods in period $t-1$ vis-à-vis country i relative to total Icelandic imports and exports of goods vis-à-vis the trading partners. Changes in the CPI_t^F from 1895 to 1896 are thus weighted with trade weights reflecting the trade composition in year 1895, etc. An increase in Xc^R describes an overall real appreciation of the króna vis-à-vis the currencies of Iceland's trading partners (Abildgren, 2004).

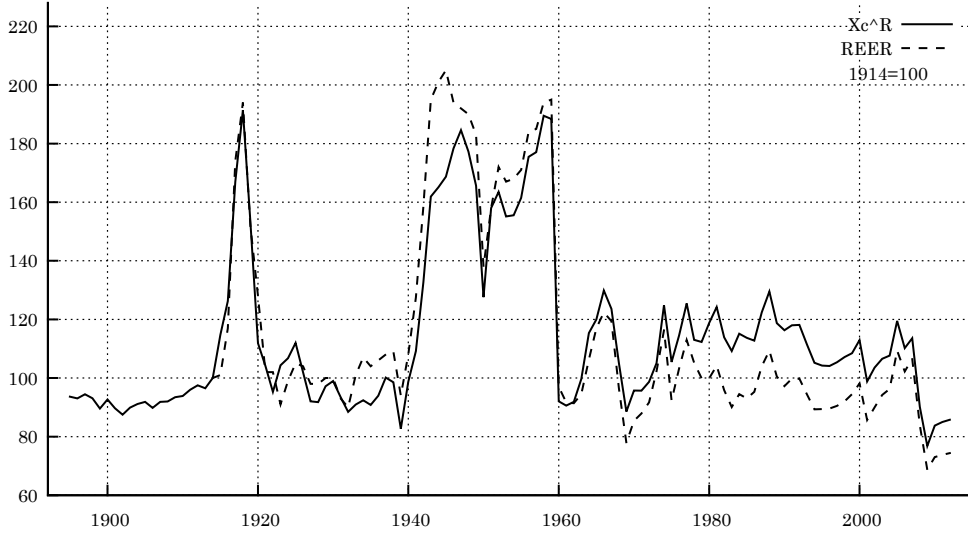


Figure 3.1: Comparison of the new historical real effective exchange rate of the Icelandic króna (Xc^R) & the official real exchange rate, annual frequency: 1895 to 2012 (1914 = 100)

Appreciation of the real exchange rate usually suggests that the country is growing wealthier, with increased competitiveness. This generally applies to foreign trade. Increased efficiency and competitiveness in non-exportable domestic services usually carries no weight in the fluctuations of a country's currency exchange rate (Froot & Rogoff, 1994).

Comparison of the developments between the new historical real effective exchange rate (Xc^R) and official data can be seen in Figure 3.1¹². Figure 3.2 shows the development of the new historical nominal effective exchange rate (Xc^N) and relative prices ($RelCPI$) for the period, in logarithmic scale¹³.

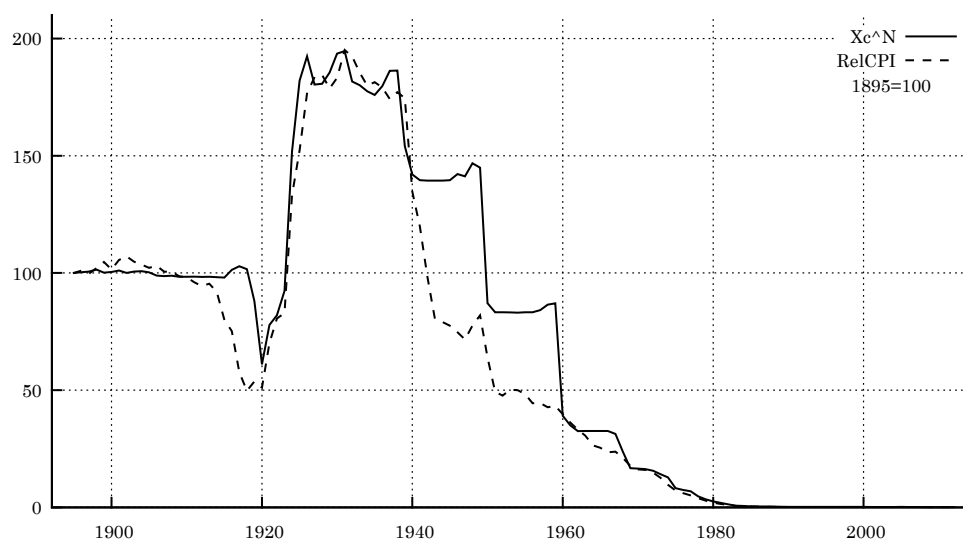


Figure 3.2: Historical nominal effective exchange rate of the Icelandic króna (Xc^N) & relative prices ($RelCPI = (CPI_t^F / CPI_t^I)$) in logarithmic scale, annual frequency: 1895 to 2012 (1895 = 100)

¹²In order to make one continuous time-series covering the whole period, annual averages are calculated from monthly data post-1988.

¹³For more figures, *cf.* Appendix III.

4 Econometric Methodology

4.1 Stationarity

The mean reverting behaviour of the real exchange rate is commonly estimated via unit-root and cointegration testing procedures. The basic idea is to test whether the Xc^R behaves like a random walk, where a variable's value equals its previous value with a stochastic term added. In such a case the time series is said to contain a unit root, *i.e.* it is non-stationary¹⁴.

The alternative hypothesis of the unit-root test in its basic form can be formulated as equation (1), where $b_1 < 1$, b_0 is a constant and the error term (e) is assumed to be independently normally distributed with a zero mean and a constant variance:

$$Xc_t^R = b_0 + b_1 Xc_{t-1}^R + e_t \quad (1)$$

Under the alternative hypothesis, the Xc^R follows a first-order autoregressive process ($AR(1)$) with non-zero mean, *i.e.* Xc^R is a stationary process that is consistent with long-run PPP convergence. Equation (1) can be rewritten as (2):

$$\begin{aligned} Xc_t^R &= Xc_{t-1}^R + (1 - b_1) \left(\frac{b_0}{1 - b_1} - Xc_{t-1}^R \right) + e_t \\ &= \frac{b_0}{1 - b_1} + b_1 \left(Xc_{t-1}^R - \frac{b_0}{1 - b_1} \right) + e_t \end{aligned} \quad (2)$$

The alternative hypothesis thus implies that the Xc^R evolves around a constant long-run level given by $b_0/(1 - b_1)$. If the Xc^R in year $t - 1$ is below (above) the long-run level, there will be a tendency for the Xc^R in year t to appreciate (depreciate). The null hypothesis of the test is $b_1 = 1$; *i.e.*, that the Xc^R follows a random walk (with drift if the constant b_0 differs from zero). Under the null hypothesis, the Xc^R is a non-stationary process, which is inconsistent with the existence of long-run PPP convergence.

So far, the alternative hypothesis in the basic version of the unit-root test, the Xc^R evolves around a constant long-run level. This rules out the presence of a

¹⁴Mean and variance change with time.

deterministic trend in the real effective exchange rate. Unit-root presence can lead to spurious correlation in regression analysis which causes parameter estimation for adjusted R^2 and t-scores to be overestimated. A trend-stationary variable is subject to non-stationary estimation, if the trend is not accounted for. Adding a time trend parameter to the model, can prevent spurious regression. A deterministic trend could be formalised in a unit-root test where the alternative hypothesis in its basic version is given by equation (3):

$$Xc_t^R = b_0 + b_1 Xc_{t-1}^R + d_t + e_t \quad (3)$$

This alternative hypothesis, where $b_1 < 1$, thus implies that the Xc^R evolves around a deterministic time trend (*i.e.* a trend-stationary process). The forces of the relative PPP ensure a long-run mean reversion towards the trend. The null hypothesis of the test is $b_1 = 1$, *i.e.* that the Xc^R follows a random walk (with drift if the constant $b_0 \neq 0$) around a deterministic trend (Abildgren, 2004).

4.1.1 Unit-root: Augmented Dickey Fuller

The ADF test has become the “standard” test for stationarity in the literature. However, it should be noted that the power of the *ADF* test is not very strong. It can therefore be difficult to reject the null hypothesis of non-stationarity even when it is false, especially if the stationary alternative has a sum of autoregressive parameters ($\sum b_j$) close to one (*i.e.* in cases where convergence towards PPP is slow).

A test of the null hypothesis ($b_1 = 1$) based on Equation (1), can be made via the basic Dickey-Fuller test (DF test) for the presence of a unit root (without a trend included). The test is based on the auxiliary regression in:

$$D_Xc_t^R = b_0 + (b_1 - 1)Xc_{t-1}^R + e_t \quad (4)$$

where $D_$ denotes the first difference operator; *i.e.* $D_Xc_t^R = Xc_t^R - Xc_{t-1}^R$. The null hypothesis ($b_1 = 1$) corresponds to $g = b_1 - 1 = 0$, and the test-statistic is the usual t value for g . However, under the null hypothesis the distribution of this statistic does not follow the usual Student’s t distribution, but a special distribution with larger (absolute) critical values. An appropriate number(ρ) of lags of $D_Xc_t^R$ may have to be added on the right hand side of Equation (4), in order to remove any autocorrelation in the residuals. This gives the Augmented Dickey Fuller test (*ADF*(ρ)*test*). The *ADF*(1) test is based, for instance, on the auxiliary regression in (5): *ADF*(1):

$$D_Xc_t^R = b_0 + \left(\sum_{j=1}^2 b_j - 1 \right) Xc_{t-1}^R - b_2 D_Xc_{t-1}^R + e_t \quad (5)$$

and $ADF(\rho)$ is based on:

$$D_-Xc_t^R = b_0 + \left(\sum_{j=1}^{\rho+1} b_j - 1 \right) Xc_{t-1}^R + \sum_{j=1}^{\rho} b_j^* D_-Xc_{t-j}^R + e_t \quad (6)$$

where b_j^* are functions of b_2, \dots, b_{p+1} . The null hypothesis of non-stationarity of the $ADF(\rho)$ test is that $g = \sum b_j - 1 = 0$ and the test-statistic is the usual t value for g . However, as it was the case in the DF-test, the distribution of this statistic is non-standard. With no significant lags, the $ADF(0)$ test is identical to the DF test. With ρ significant lags in an $ADF(\rho)$ test, the Xc^R follows an $(\rho+1)$ -order autoregressive path under the alternative hypothesis ($\sum b_j < 1$)¹⁵:

$$Xc_t^R = b_0 + \sum_{j=1}^{\rho+1} b_j Xc_{t-j}^R + e_t \quad (7)$$

(7) can be rewritten as (8):

$$Xc_t^R = \frac{b_0}{1 - \sum_{j=1}^{\rho+1} b_j} + \sum_{j=1}^{\rho+1} \left(b_j \left[Xc_{t-j}^R - \frac{b_0}{1 - \sum_{j=1}^{\rho+1} b_j} \right] \right) + e_t \quad (8)$$

The alternative hypothesis thus implies that the Xc^R evolves around a constant long-run level given by $b_0/(1 - \sum b_j)$ (Abildgren, 2004).

4.1.2 Cointegration: Engle-Granger Single-Equation

After unit-root testing, determining order of integration is the next logical step in determining whether the variables share a similar stochastic trend; that is, discovering whether cointegration relationships exist between them. Consider again the simple first-order autoregressive model in Equation (1). If Xc_t^R follows a random walk, then $b_1 = 0$. If the error term e_t is stationary, *i.e.*, does not follow a random walk then the first difference $D_-Xc_t^R = Xc_t^R - Xc_{t-1}^R$ is also stationary:

$$Xc_t^R = b_0 + b_1 Xc_{t-1}^R + e_t$$

$$D_-Xc_t^R = Xc_t^R - Xc_{t-1}^R = e_t$$

The cointegration test is essentially a stationarity test of the residuals. (Griffiths *et al.*, 2008). Cointegration entails that the error terms e_t are stationary, which means that they never diverge too far from each other. Cointegration holds that the

¹⁵The number of lags in the ADF test, has been chosen so that autocorrelation is minimized in the residuals from the auxiliary regression.

combination of two or more non-stationary series can yield a long-run relationship as long as the series are integrated of the same order, non-stationarity can therefore be cancelled out, and a stationary relationship observed instead (Beirne, 2010).

Cointegration consists of matching the degree of non-stationarity of the variables in an equation in a way that makes the error term and residuals of the equation stationary and rids the equation of any spurious regression estimation (Studenmund, 2011).

The Engle-Granger single-equation cointegration test is an alternative way to the unit-root for relative PPP assessment. Should relative PPP hold, the real effective króna rate must be equal to a constant (K):

$$Xc^R = \frac{Xc^N CPI_t^I}{CPI_t^F} = \frac{Xc_t^N}{(CPI_t^F / CPI_t^I)} = \frac{Xc_t^N}{RelCPI_t} = K \quad (9)$$

Where Xc^N is the nominal effective króna rate and $RelCPI = (CPI_t^F / CPI_t^I)$ is the ratio between the domestic and foreign price indices. Adding an error term (e) which is assumed to be independently normally distributed with a zero mean and constant variance, (9) becomes:

$$\ln(Xc_t^N) - \ln(RelCPI_t) = \ln(K) + e_t \quad (10)$$

If $\ln(Xc_t^N)$ and $\ln(RelCPI_t)$ are both integrated of first order ($I(1)$), they are cointegrated if the natural logarithm of the real effective króna rate is stationary ($\ln(Xc_t^R) = \ln(Xc_t^N) - \ln(RelCPI_t)$). This can be evaluated via *ADF* tests on $\ln(Xc_t^N)$, $\ln(RelCPI_t)$ and $\ln(Xc_t^R)$. If $\ln(Xc_t^N)$ and $\ln(RelCPI_t)$ are $I(1)$ and $\ln(Xc_t^R)$ is stationary, the results support a hypothesis of long-run relative PPP convergence, and the cointegrating relationship implied by equation (10) can be viewed as the long-term relationship between $\ln(Xc_t^N)$ and $\ln(RelCPI_t)$. If $\ln(Xc_t^N)$ and $\ln(RelCPI_t)$ are both stationary, then the $\ln(Xc_t^R)$ is also stationary. This also gives support for long-run relative PPP. If stationarity of $\ln(Xc_t^R)$ is rejected, there is no support for relative PPP (Abildgren, 2004).

4.2 Mean-Reversion

4.2.1 Half-Life Estimation

The validity of long-run PPP depends not just on the absence of a unit-root in time series. A sufficient degree of mean-reversion in the real exchange rate is also important if PPP assumption-based models are to have real-world meaning (Cashin & McDermott, 2003).

In a first-order autoregressive process ($AR(1)$) such as Equation (2), parameter

b_1 determines the speed of mean reversion, since $(1 - b_1)$ per cent of the absolute deviation from the long-run level is expected to close each year. The number of years before one-half of a deviation from the long-run level of the real effective exchange rate is extinguished, the so-called *Half-life (HL)* can be found as:

$$HLin(1) = \frac{\ln(0.5)}{\ln(b_1)} \quad (11)$$

where \ln denotes the natural logarithmic function. For an $AR(\rho)$ process, a commonly used approximate formula for the number of years before one-half of a shock to the real effective exchange rate is extinguished when estimating is given by:

$$HLin(6) = \frac{\ln(0.5)}{\ln\left(\sum_{j=1}^{p+1} b_j\right)} \quad (12)$$

Ordinary least squares (OLS) estimates of the parameters to the lagged dependent variables in Equations (1), and (6) will be downward biased in finite even when the Xc^R is stationary. In a linear framework, half-lives can only be considered as a simple “summary measure” of mean reversion, as speed of adjustment may not always be uniform (Abildgren, 2004)¹⁶.

4.2.2 Bias-Adjusted Half-Life Estimation

More accurate estimations for half-life analysis in a linear autoregressive framework might be achieved through bias adjusted estimation. A downward bias in the parameters implies that point estimates for half-lives will be too low when calculated from OLS estimates (Abildgren, 2004). In the case of the $AR(1)$ -model for Xc^R , a bias-adjusted half-life may be calculated from the OLS estimate as bias-adjusted OLS estimate for half-life in $AR(1)$ model for Xc^R :

$$\frac{\ln(0.5)}{\ln\left(\frac{b_1 N}{N-3} + \frac{1}{N-3}\right)}$$

where N denotes the number of observations. In the case of an $AR(2)$ -model for the Xc^R , a bias-adjusted approximate half-life may be calculated from the OLS estimates as the bias-adjusted OLS estimate for half-life in $AR(2)$ model for Xc^R .

$$\frac{\ln(0.5)}{\ln\left(\frac{b_1 N}{N-1} + \frac{1}{N-1} + \left(\frac{1}{N-1} + 1\right)\left(\frac{b_2 N}{N-4} + \frac{2}{N-4}\right)\right)}$$

¹⁶A time trend parameter, is usually not included in half-life estimation, as it is not consistent with the idea of mean reversion (Cashin & McDermott, 2003).

5 Empirical Findings

5.1 1895 to 2012

5.1.1 Unit-Root

Table 5.1: Unit-root test results for the period 1895-2012, annual data.

Unit-root tests for the period 1895 to 2012	No trend	Trend incl.
ADF test statistic on Xc^R (<i>lags</i>) ^(I)	-3.55** (1)	-3.5** (1)
AR-model Parameter estimates (OLS) ^(II)		
d	n.a.	-0.005
b_0	15.3**	15.55**
b_1	1.06**	1.058**
b_2	-0.23**	-0.23**
Adjusted R^2	0.75	0.74
LM test for autocorrelated residuals ^(III)		
Lag 1	0.24	0.25
Lag 1-2	0.16	0.17
Lag 1-3	0.19	0.18
Lag 1-4	0.49	0.52
Test for heteroskedasticity in residuals ^(IV)		
Levels & squares of regressors (squares only)	24.64**	24.98**
Levels squares & cross products of regressors	25.23**	28.43**
Test of normality of residuals ^(V)	73.72**	72.71**
OLS estimates of half-life in years (<i>Adj. estim.</i>)	3.6 (4.4)	3.7 (4.4)

“*” & “**” denotes rejection of the null hypothesis at a 10% and 5% significance level respectively

(I): Null hypothesis is Non-stationarity. (II): Null hypothesis: Coefficient equal to zero. (III): F-test null hypothesis is no autocorrelation. (IV): Chi-square null hypothesis is no heteroskedasticity. (V): Chi-square null hypothesis is Normality.

Estimation results for the period as a whole support long-run relative purchasing power parity convergence. The null hypothesis of non-stationarity is rejected at a 5 per cent significance level, both with and without a trend parameter present. Estimations show no trace of autocorrelation in the residuals; however, heteroskedasticity and non-normality of the residuals are evident. The underlying univariate autoregressive models explain around 75 per cent of the linear variation in the real effective exchange rate for the period.

Although insignificant, the negative sign for the trend parameter could indicate a slow decline in Iceland's competitiveness relative to its major trading partners over the period. Another possible explanation could be due to biased parameter estimates, caused by an unknown structural-break in the series.

5.1.2 Cointegration

Table 5.2: Single-equation cointegration test result for the period 1895-2012, annual data.

Cointegration tests for the period 1895 to 2012	No trend	(lags)
ADF test statistic on $\log(Xc^R)^{(I)}$	-3.43**	(1)
LM test for autocorrelated residuals ^(II)		
Lag 1	0.012	
Lag 1-2	0.014	
Lag 1-3	0.065	
Lag 1-4	0.408	
Test for heteroskedasticity in residuals ^(III)		
Levels & squares of regressors (squares only)	17.19**	
Levels squares & cross products of regressors	17.87**	
Test of normality of residuals ^(IV)	49.50**	
ADF test statistic on $\log(Xc^N)^{(I)}$	1.117	(1)
ADF test statistic on $D_log(Xc^N)^{(I)}$	-7.22**	(0)
ADF test statistic on $\log(RelCPI)^{(I)}$	-0.360	(5)
ADF test statistic on $D_log(RelCPI)^{(I)}$	-4.97**	(0)

“*” & “**” denotes rejection of the null hypothesis at a 10% and 5% significance level respectively

(I) Null hypothesis: Non-stationarity (II) F-test null hypothesis: No autocorrelation (III) Chi-square null hypothesis: No heteroskedasticity. (IV) Chi-square null hypothesis: Normality.

OLS half-life estimates for the period are around 3.6 years, and around 4.4 years when adjusted for bias¹⁷. Results from single-equation cointegration tests confirm previous results of stationarity. Unit-root presence is rejected in $\log(Xc^R)$ at a 5 per cent significance level. Although unit-root presence in $\log(Xc^N)$ and $\log(RelCPI)$ cannot be rejected, it is rejected for the first difference of both series which makes them integrated of first order $I(1)$. Stationarity of $\log(Xc^R)$ also indicates a cointegration relationship between $\log(Xc^N)$ and $\log(RelCPI)$.

¹⁷Bias-adjusted half-life estimates produce longer half-life times, which is consistent with *a priori* expectations.

5.2 Structural Break Estimation

5.2.1 QLR Unknown Breakpoint Estimation

Structural breaks in time-series that are not accounted for, can lead to biased parameter estimates. They can also lead unit-root tests to falsely accept a null hypothesis of non-stationarity (Byrne & Perman, 2006).

Although visual inspection of time-series can give indication of structural breaks, empirical testing is necessary to determine specific breakpoint dates. The Chow test is commonly used to test for structural breaks. The test essentially splits the sample into two sub-periods, evaluates the parameters for each sub-period, and compares the F statistics. The Chow test is given by:

$$F_n\left(\frac{m}{n}\right) = F_n(\lambda) = \frac{(SSR_{1,n} - (SSR_{1,m} + SSR_{m+1,n}))/k}{(SSR_{1,m} + SSR_{m+1,n})/(n-2k)}$$

where SSR is the sum of squared residuals. The main disadvantage of using the Chow test is that it requires *a priori* knowledge about brake dates. Choosing a breakpoint based on knowledge about the data can lead to true break dates being overlooked. Possible candidates can be endogenous; *e.g.*, correlated with the data, *etc.*

An alternative approach to the Chow test is Quandt's LR test with an unknown break date, also known as the QLR test (Hansen, 2001). The QLR test does not require knowledge about breakpoints beforehand. The QLR test applies a series of Chow tests to all possible breakpoints in the time-series and plots the test statistic. The QLR test is given by:

$$QLR = \max_{m \in [m_0, m_1]} F_n\left(\frac{m}{n}\right) = \max_{\lambda \in [\lambda_0, \lambda_1]} F_n(\lambda)$$

$$\lambda_i = \frac{m_i}{n} = \text{trimming parameters}, i = 0, 1$$

When testing for unknown break dates, the usual χ^2 likelihood distribution is not appropriate. χ^2 critical values can lead to breakpoints being estimated as significant when they are not. Andrews (1993) provides a table of asymptotic critical values that give a more accurate likelihood distribution, appropriate for the Quandt statistic assessment. These values are considerably larger than χ^2 asymptotic critical values and therefore less likely to reject a null hypothesis of no structural break¹⁸.

¹⁸The largest break test-point on the graph is called the Quandt statistic, after Richard E. Quandt who proposed the test.

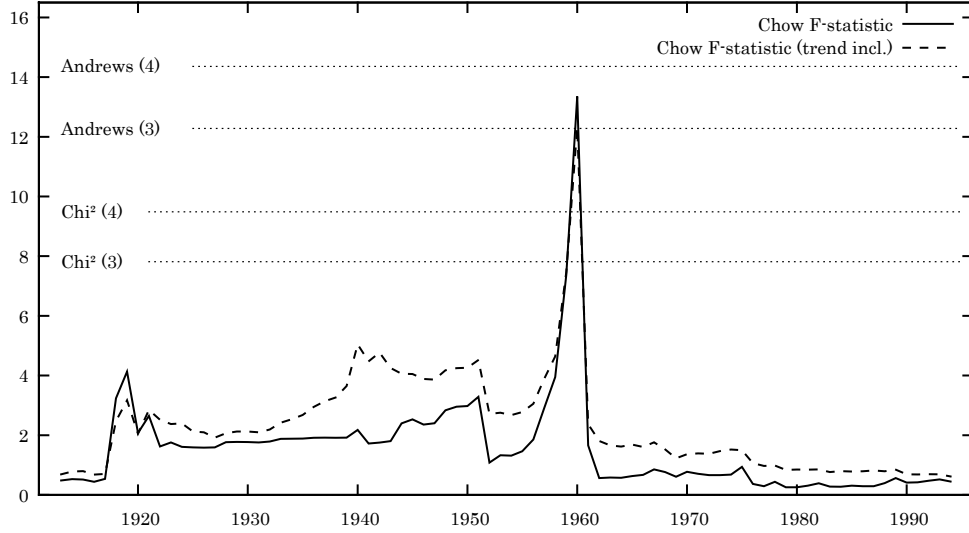


Figure 5.1: QLR unknown structural break test for the period 1913 to 1994, w. 15 per cent trimming ($\lambda_{0.15}$)

In Figure 5.1, estimated Chow statistics have been plotted as a function of break dates, covering the period from 1913 through 1994¹⁹. The visible peaks at 1960 are the Quandt statistics with the estimated values 40.1 and 49.3 for the solid and dotted line, respectively. Also plotted on the graph are horizontal lines representing the following asymptotic critical values: $\chi^2_{0.95}(3) = 7.81$, $\chi^2_{0.95}(4) = 9.49$, $Andrews CV_{0.9}(\rho_3, \lambda_{0.15}) = 12.28$ and $Andrews CV_{0.9}(\rho_4, \lambda_{0.15}) = 14.36$ ²⁰. Break-points too close to the beginning or end of a sample cannot be considered, as there are not enough observations to identify the sub-sample parameters (Hansen, 2001). Andrews (1993) recommends 15 per cent trimming ($\lambda_{0.15}$) of each end if no prior knowledge of brake-dates exists.

Both critical values for the χ^2 likelihood distribution reject the null hypothesis of no structural break at a 5 per cent significance level by a substantial margin. $Andrews CV_{0.9}(\rho_3, \lambda_{0.15})$ also rejects the null hypothesis of no structural break at a 10 per cent significance level. For the period de-trended, structural break presence cannot be rejected at 10 per cent significance level based on $Andrews CV_{0.9}(\rho_4, \lambda_{0.15})$.

A CUSUMQ test supports the previous QLR test results, by rejecting variance stability at a 95 per cent confidence level at the same breakpoint, *i.e.* 1960 (*cf.* Figure 5.2).

Historical interpretations might support a possible structural breakpoint at 1960. During the years leading up to 1960 a complex multiple exchange rate system was in place. The official ISK exchange rate during the period from 1951 to 1960 was not

¹⁹The dotted line represents the time period de-trended.

²⁰ χ^2 critical values are at a 5 per cent significance level. Andrews critical values are at a 10 per cent significance level.

registered correctly. The period is characterized by heavy import restrictions, tariffs, and strict capital controls (Magnússon, 2012)²¹.

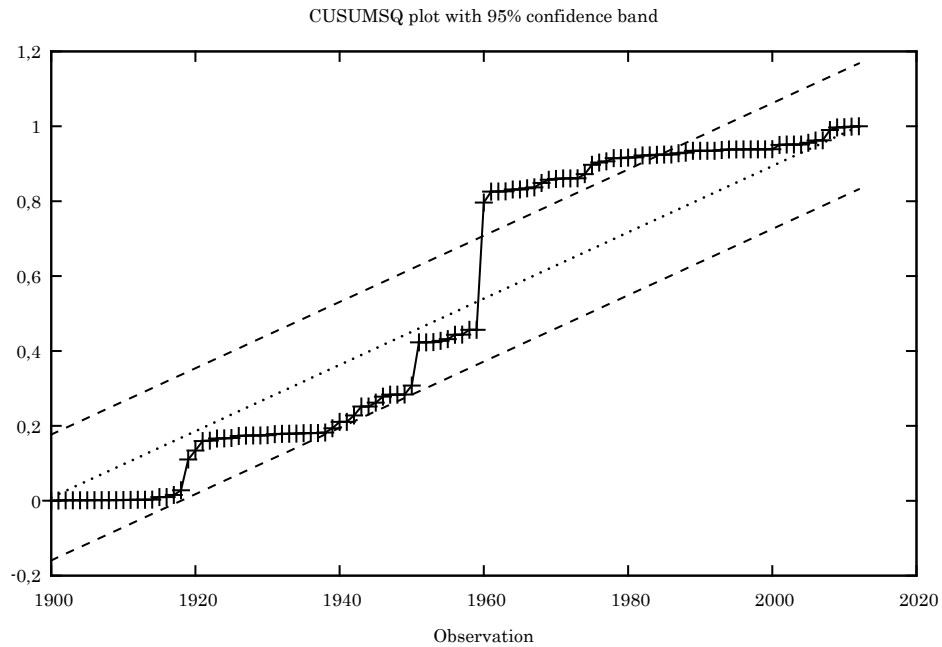


Figure 5.2: CUSUMQ parameter stability tests for the period 1895 to 2012.

²¹A so-called “*Boat-currency-system*” was put in place to support the marine export sector, mostly at the expense of the importing sectors.

5.3 1895 to 1960

5.3.1 Unit-Root

Table 5.3: Unit-root test results for the period 1895-1960, annual data.

Unit-root tests for the period 1895 to 1960	No trend	Trend incl.
ADF test statistic on Xc^R (<i>lags</i>) ^(I)	-2.81* (1)	-3.07 (1)
AR-model Parameter estimates (OLS) ^(II)		
d	n.a.	n.a.
b_0	15.97**	n.a.
b_1	1.24**	n.a.
b_2	-0.42**	n.a.
Adjusted R^2	0.76	n.a.
LM test for autocorrelated residuals ^(III)		
Lag 1	1.01	0.53
Lag 1-2	0.59	0.44
Lag 1-3	0.48	0.41
Lag 1-4	0.50	0.38
Test for heteroskedasticity in residuals ^(IV)		
Levels & squares of regressors (squares only)	13.31**	13.01**
Levels squares & cross products of regressors	13.57**	19.68**
Test of normality of residuals ^(V)	44.25**	44.91**
OLS estimates of half-life in years (<i>Adj. estm.</i>)	3.5 (4.7)	n.a.

“*” & “**” denotes rejection of the null hypothesis at a 10% and 5% significance level respectively

For the 1895-1960 period, non-stationarity is rejected at a 10 per cent significance level without trend²². Estimations show no trace of autocorrelation in the residuals. Heteroskedasticity and non-normality presence in the residuals is not rejected. The underlying univariate autoregressive models explain around 76 per cent of the linear variation in the real exchange rate for the period. Mean-reversion estimation produces similar results to the half-life estimates for the period as a whole, around 3.5 years, and 4.7 years when adjusted for bias.

(I) Null hypothesis: Non-stationarity (II) Null hypothesis: Coefficient equal to zero (III) F-test null hypothesis: No autocorrelation (IV) Chi-square null hypothesis: No heteroskedasticity. (V) Chi-square null hypothesis: Normality.

²²For the de-trended period, unit-root presence could not be rejected, parameter estimates were therefore omitted.

5.3.2 Cointegration

Table 5.4: Single-equation cointegration test result for the period 1895-1960, annual data.

Cointegration tests for the period 1895 to 1960	No trend	(lags)
ADF test statistic on $\log(Xc^R)^{(I)}$	-2.62*	(1)
LM test for autocorrelated residuals ^(II)		
Lag 1	0.25	
Lag 1-2	0.12	
Lag 1-3	0.10	
Lag 1-4	0.19	
Test for heteroskedasticity in residuals ^(III)		
Levels & squares of regressors (squares only)	10.25**	
Levels squares & cross products of regressors	10.39*	
Test of normality of residuals ^(IV)	37.32**	
ADF test statistic on $\log(Xc^N)^{(I)}$	-0.414	(0)
ADF test statistic on $D_log(Xc^N)^{(I)}$	-4.72**	(0)
ADF test statistic on $\log(RelCPI)^{(I)}$	-0.92	(1)
ADF test statistic on $D_log(RelCPI)^{(I)}$	-5.08**	(0)

“*” & “**” denotes rejection of the null hypothesis at a 10% and 5% significance level respectively

Cointegration tests confirm the results for the period. Non-stationarity of $\log(Xc^R)$ is rejected at a 10 per cent significance level. Unit-root presence in $\log(Xc^N)$ and $\log(RelCPI)$ cannot be rejected. The two variables are both integrated of first order ($I(1)$), as unit-root presence is rejected for the first difference of both series. The stationarity result for $\log(Xc^R)$ suggests that $\log(Xc^N)$ and $\log(RelCPI)$ are cointegrated.

(I) Null hypothesis: Non-stationarity (II) F-test null hypothesis: No autocorrelation (III) Chi-square null hypothesis: No heteroskedasticity. (IV) Chi-square null hypothesis: Normality.

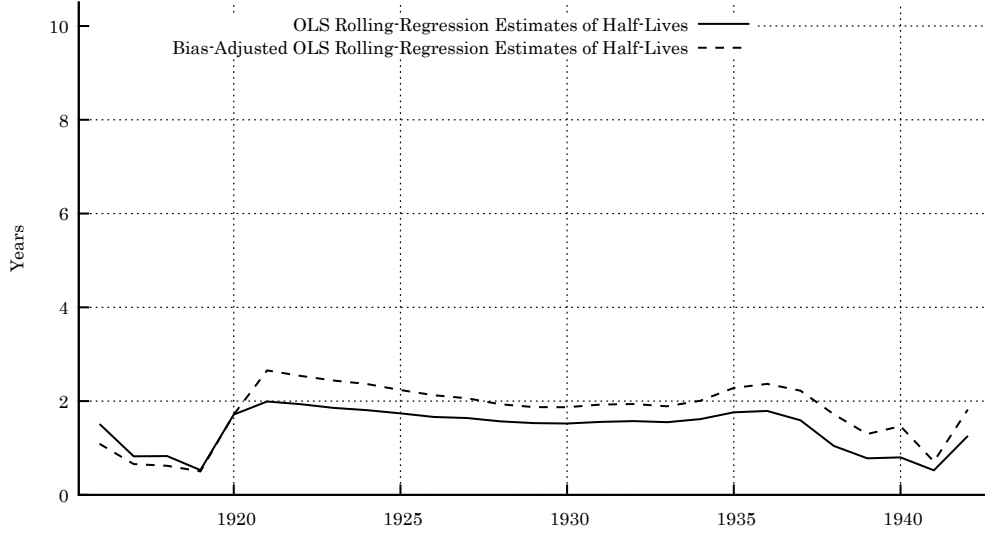


Figure 5.3: OLS estimates of half-lives in a 20-year rolling-window regression of AR(2)-model for Xc^R . Period 1916 to 1942, annual frequency.

Prior to 1922, during the classical gold standard period, the Icelandic króna was pegged to the Danish krone. The two currencies were separated in 1922 due to imbalances that had developed during World War I. The years leading up to World War II were characterized by relative stability in Iceland (Guðmundsson *et al.*, 2001). Uniform and stable half-life estimates are seen throughout the period, *cf.* Figure 5.3²³.

²³Rolling half-life estimates for the period between 1943 and 1960 were omitted.

5.4 1960 to 2012

5.4.1 Unit-Root

Table 5.5: Unit-root test results for the period 1960-2012, annual data.

Unit root tests for the period 1960 to 2012	No trend	Trend incl.
ADF test statistic on Xc^R (<i>lags</i>) ^(I)	-3.13** (<i>3</i>)	-2.85 (<i>0</i>)
AR-model Parameter estimates (OLS) ^(II)		
d	n.a.	n.a.
b_0	27.1**	n.a.
b_1	0.85**	n.a.
b_2	-0.17	n.a.
Adjusted R^2	0.51	n.a.
LM test for autocorrelated residuals ^(III)		
Lag 1	0.28	0.64
Lag 1-2	0.45	0.42
Lag 1-3	1.1	0.32
Lag 1-4	1.21	0.48
Test for heteroskedasticity in residuals ^(IV)		
Levels & squares of regressors (squares only)	1.11	8.13*
Levels squares & cross products of regressors	8.96	9.19
Test of normality of residuals ^(V)	1.74	2.06
OLS estimates of half-life in years (<i>Adj. estm.</i>)	1.8 (<i>2.3</i>)	n.a.

“*” & “***” denotes rejection of the null hypothesis at a 10% and 5% significance level respectively

Estimations for the post-1960 period reject a null hypothesis of non-stationarity at a 5 per cent significance level with no trend²⁴. No traces of autocorrelation, heteroskedasticity or non-normality are evident in the residuals. Around 51 per cent of the linear variations in the real exchange rate for the period are explained by the underlying autoregressive models. Mean-reversion estimation produce significantly lower half-life estimates for the period, compared to the pre-1960 period, with half-life estimates at 1.8 years, bias-adjusted at 2.3 years.

(I) Null hypothesis: Non-stationarity (II) Null hypothesis: Coefficient equal to zero (III) F-test null hypothesis: No autocorrelation (IV) Chi-square null hypothesis: No heteroskedasticity. (V) Chi-square null hypothesis: Normality.

²⁴For the de-trended period, unit-root presence could not be rejected, parameter estimates were therefore omitted.

5.4.2 Cointegration

Table 5.6: Single-equation cointegration test result for the period 1960-2012, annual data.

Cointegration tests for the period 1960 to 2012	No trend	(lags)
ADF test statistic on $\log(Xc^R)^{(I)}$	-3.07**	(3)
LM test for autocorrelated residuals ^(II)		
Lag 1	0.24	
Lag 1-2	0.46	
Lag 1-3	1.21	
Lag 1-4	1.26	
Test for heteroskedasticity in residuals ^(III)		
Levels & squares of regressors (squares only)	0.4	
Levels squares & cross products of regressors	9.8*	
Test of normality of residuals ^(IV)	4.27	
ADF test statistic on $\log(Xc^N)^{(I)}$	-1.46	(0)
ADF test statistic on $D_log(Xc^N)^{(I)}$	-4.16**	(0)
ADF test statistic on $\log(RelCPI)^{(I)}$	-2.38	(0)
ADF test statistic on $D_log(RelCPI)^{(I)}$	-2.43	(0)

“*” & “**” denotes rejection of the null hypothesis at a 10% and 5% significance level respectively

Previous results are supported by unit-root rejection for $\log(Xc^R)$ at a 5 per cent significance level. However, $\log(Xc^N)$ and $\log(RelCPI)$ are not integrated, as unit-root presence is not rejected for $\log(RelCPI)$, or for the first difference of the series ($D_log(RelCPI)$).

Rolling half-life estimates show increased volatility leading up to the collapse of Bretton-Woods, *cf.* Figure 5.4. Post Bretton-Woods, floating became widespread and so did currency fluctuations and volatility²⁵. The majority of Iceland’s trading partners floated their currencies. Managed floating better describes the Icelandic currency scheme during the period (Guðmundsson *et al.*, 2001)²⁶.

(I) Null hypothesis: Non-stationarity (II) F-test null hypothesis: No autocorrelation (III) Chi-square null hypothesis: No heteroskedasticity. (IV) Chi-square null hypothesis: Normality.

²⁵The króna was replaced with a “new” króna at a 100:1 ratio in January of 1981.

²⁶Alongside increased floating came inflation, which went rampant in Iceland during the 1980s.

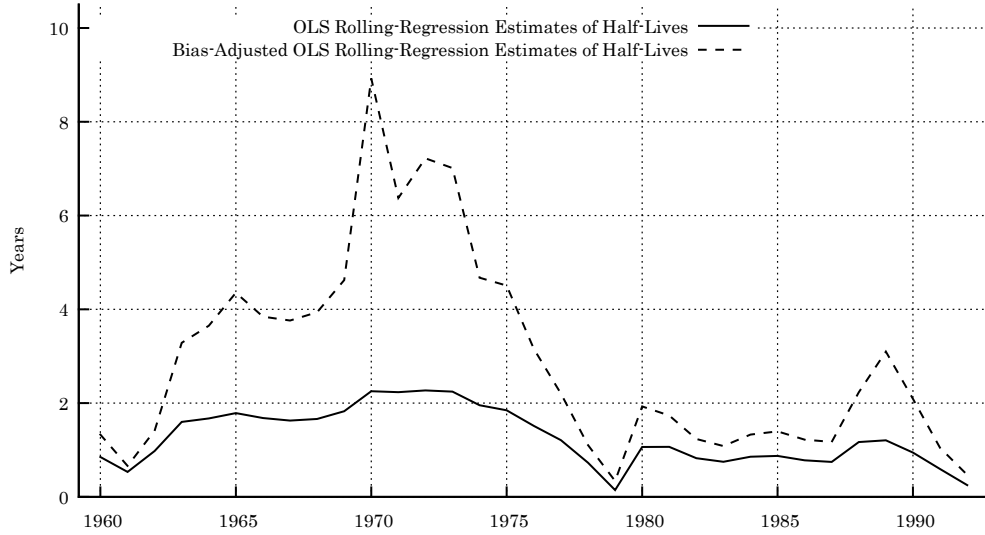


Figure 5.4: OLS estimates of half-lives in a 20-year rolling-window regression of AR(2)-model for Xc^R . Period 1960 to 1992, annual frequency.

A considerable difference between unadjusted half-life estimates (solid line) and the bias-adjusted half-life estimates (dotted line) is visible. Unadjusted estimates show no dramatic changes during the period²⁷. Bias-adjusted estimates show a substantial increase in half-life duration early in the period, peaking around 1970, with close to 9 year estimates, before slowly subsiding from then on²⁸.

²⁷In early 1990 a national stability pact was signed. The pact was an agreement between the labour force and the Government, calling for an end to the wage-price spiral caused by wage demands on top of increasing prices. Formal Government policy emphasizing exchange rate stability at the same time, drove inflation down. Relative stability ensued (Snævarr, 1993).

²⁸Price Indexation was implemented in the early 1980s, might help explain lower half-life estimates post-1980.

5.5 Monthly Data

5.5.1 Unit-Root

Table 5.7: Unit-root test results for the period 1988-2012, monthly data.

Unit root tests for the period 1988m01 to 2012m12	No trend	Trend incl.
ADF test statistic on Xc^R (<i>lags</i>) ^(I)	-2.45 (1)	-3.25* (1)
AR-model Parameter estimates (OLS) ^(II)		
d	n.a.	-0.004**
b_0	n.a.	4.39**
b_1	n.a.	1.31**
b_2	n.a.	-0.48**
b_3	n.a.	0.19*
b_4	n.a.	-0.11
b_5	n.a.	0.09
b_6	n.a.	-0.11
b_7	n.a.	0.33**
b_8	n.a.	-0.25**
Adjusted R^2	n.a.	0.97
LM test for autocorrelated residuals ^(III)		
Lag 1	2.02	1.42
Lag 1-2	2.02	2.01
Lag 1-3	1.38	1.45
Lag 1-4	1.08	1.09
Test for heteroskedasticity in residuals ^(IV)		
Levels & squares of regressors (squares only)	75.05**	116.14**
Levels squares & cross products of regressors	186.7**	209.83**
Test of normality of residuals ^(V)	59.40**	67.67**
OLS estimates of half-life in years (<i>Adj. estm.</i>)	n.a.	n.a. (1.1)

“*” & “**” denotes rejection of the null hypothesis at a 10% and 5% significance level respectively

(I) Null hypothesis: Non-stationarity (II) Null hypothesis: Coefficient equal to zero (III) F-test null hypothesis: No autocorrelation (IV) Chi-square null hypothesis: No heteroskedasticity. (V) Chi-square null hypothesis: Normality.

Using monthly data, non-stationarity is rejected at a 10 per cent significance level for the period, with trend included²⁹. No traces of autocorrelation are evident; however, the presence of heteroskedasticity and non-normality of the residuals cannot be rejected. The underlying univariate autoregressive models explain around 97 per cent of the linear variation in the real effective exchange rate for the period. Bias-adjusted half-life estimates are around 1.1 years, in duration.

The negative sign for the time trend parameter is statistically significant. It could indicate that Iceland's competitiveness relative to its trading partners declined during the period. Another explanation might be due to the fact that carry trade was prevalent during a large portion of the period. High interest rates in Iceland, during the so-called “*boom years*” attracted significant capital inflows, resulting in a considerable appreciation of the ISK. Such effects on exchange rates caused by capital movements, not involving trade with goods, are not accounted for in the PPP framework³⁰.

A 10-year rolling window of half-life estimates, shows substantial fall in half-life duration, after the floating of the ISK in early 2001 (*cf.* Figure 5.5), from estimates just over two years in duration, down to 10 months. A sharp rise noticeable at the end of 2008, when the global recession struck.

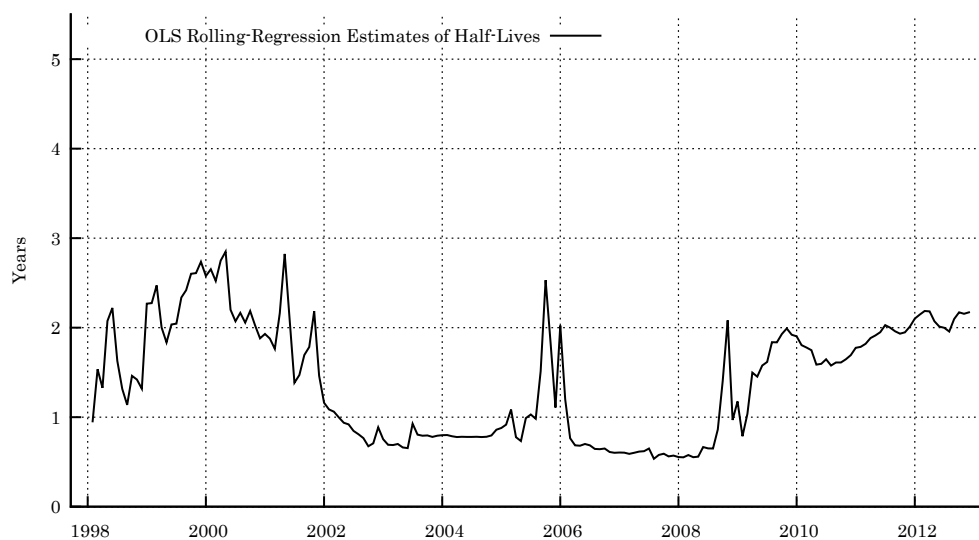


Figure 5.5: OLS estimates of half-lives in a 120-month rolling-window regression of AR(2)-model for Xc^R . Period 1998 to 2012, monthly frequency.

²⁹For the period without a trend parameter, unit-root presence could not be rejected, parameter estimates were therefore omitted.

³⁰*Cf.* uncovered interest rate parity discussion in Section 2.

Two sharp peaks in late 2005 and early 2006, are likely caused by a so-called mini-crisis that occurred at the time when the Icelandic banks began to attract international attention, due to critical coverage concerning they're rapid growth in previous years (Guðmundsson, 2010).

5.5.2 Cointegration

Table 5.8: Single-equation cointegration test result for the period 1988-2012, monthly data

Cointegration tests for the period 1988m01 to 2012m12	No trend	(lags)
ADF test statisitc on $\log(Xc^R)^{(I)}$	-2.22	(1)
LM test for autocorrelated residuals ^(II)		
Lag 1	2.01	
Lag 1-2	1.99	
Lag 1-3	1.62	
Lag 1-4	1.32	
Test for heteroskedasticity in residuals ^(III)		
Levels & squares of regressors (squares only)	106.28**	
Levels squares & cross products of regressors	216.54**	
Test of normality of residuals ^(IV)	125.23**	
ADF test statistic on $\log(Xc^N)^{(I)}$	-1.419	(1)
ADF test statistic on $D_log(Xc^N)^{(I)}$	-10.80**	(1)
ADF test statistic on $\log(RelCPI)^{(I)}$	-1.64	(0)
ADF test statistic on $D_log(RelCPI)^{(I)}$	-10.62**	(0)

“*” & “**” denotes rejection of the null hypothesis at a 10% and 5% significance level respectively

Results from cointegration tests contradict previous results for the period. Stationarity is rejected for $\log(Xc^R)$. Unit-root presence in $\log(Xc^N)$ and $\log(RelCPI)$, cannot be rejected, as well. The first differences of both variables reject unit-root presence, which indicates first order integration ($I(1)$), between the two series, but cointegration relationship does not exists.

(I) Null hypothesis: Non-stationarity (II) F-test null hypothesis: No autocorrelation (III) Chi-square null hypothesis: No heteroskedasticity. (IV) Chi-square null hypothesis: Normality.

6 Conclusion

This study has explored the validity of the purchasing power parity in the case of Iceland. New historical nominal- and real effective exchange rate indices were constructed for the Icelandic króna, covering the period from 1895 through 2012. The indices are based on annual data for the period between 1895 and 1988 and monthly data from 1988 through 2012. They are constructed as geometrically weighted chain indices with current trade weights based on Iceland's foreign trade in goods. Consumer prices (CPI) are used for deflators. The annual data are based on 13 of Iceland's largest trading partners, which accounted for at least 70 per cent of Iceland's total foreign trade in good each year during the period. For the monthly data, two countries are added to the previous list of trading partners. Adding up to a total of 15 of Iceland's largest trading partners, which accounted for at least 64 per cent of Iceland's total foreign trade in goods each month throughout the period.

For empirical estimation, unit-root and cointegration tests were performed on the new time-series as a whole, and for two sub-periods that emerged after structural break estimation revealed a breakpoint at 1960. Empirical tests were also performed separately for the monthly data. The mean-reversion from PPP deviation was analysed via autoregressive models, with half-life calculations using ordinary least squares (OLS) parameter estimates.

The results of unit-root and cointegration tests support long-run relative purchasing power parity convergence for Iceland. Estimations from both sub-periods showed similar results in support of PPP convergence³¹. Contradicting test results for the post-1988 period, indicates a failure of PPP convergence for that period.

Half-lives for the period as a whole, are estimated at around four years in duration, pre-1960 half-lives are also estimated at around four years. The post-1960 period produces slightly lower half-life estimates, at around two years in length.

The most rapid mean-reversion is seen in the floating period between 2001 and 2008, with half-life estimates around 10 months. Excluding the floating period the inter-war and post-1981 periods show the most rapid mean reversion, with half-life estimates ranging from 18 to 24 months. The inter-war period is also the least volatile in the ISK's history, relative to the trading countries³².

³¹Stationarity is rejected for both de-trended sub-periods individually, but not for the period as a whole, which might be explained by a structural break presence at 1960.

³²Unfortunately rolling estimates do not extend back further than 1915 due to data shortage. Historically, the pre-1914 period was characterized by relative stability. Iceland was under Danish

The results are consistent with results from similar studies on purchasing power parity. Evidence in support of PPP validation in the long run is found, with half-life estimates from PPP deviations that fall right in the middle of the average half-life duration of 3-5 years, seen in similar studies (Rogoff, 1996). The relatively low half-life estimates in the post-Bretton-Woods are also consistent with the results of Cashin & McDermott (2003). They concluded that shocks to the real exchange rate do not appear to be very persistent in the case of the Icelandic króna, relative to real exchange rates of other currencies they examined.

The various tests for relative PPP in this study have been simple and should be considered as a first exploratory examination of the new historical time-series for the real effective exchange rate of the ISK. A combination of the PPP and UIP framework for estimation, might shed light on the results obtained here, especially for the period between 2001 and 2008. For a robustness review of the results proposed here, a non-linear framework using non-aggregated deflator indices as suggested by Taylor (2004), could prove an interesting next step in purchasing power parity examination for Iceland.

rule and was therefore, by extension, a part of the Nordic Council Monetary Union, which meant that all the Nordic currencies, *i.e.* the Danish-, Norwegian-, Swedish- and Icelandic Krona had the same value. This was during the classical gold standard period, when Nordic and most trading partner's currencies were pegged to gold (Guðmundsson *et al.*, 2001).

I Appendix

Annual data:

Bilateral exchange rates for the Danish krona *vis-à-vis* Finland, France, Germany, Italy, Japan, the Netherlands, Norway, Portugal, Spain, Sweden, the UK, and the US, for the period 1895-1988 were obtained from Abildgren (2004). Based on an assumption of perfect international arbitrage cross-currency calculations were made *vis-à-vis* the Icelandic króna and other currencies, using the bilateral exchange rate of the ISK *vis-à-vis* the Danish krone, with an exception during the period 9 April 1940 to 8 September 1945, when the US dollar is used as a cross reference due to the quotation suspension of the Danish krone. Official exchange rate quotations for the ISK versus foreign currencies began on 13 June 1922. Exchange rates before that date are calculated from the króna's gold value (Iceland historical statistics, 1997).

Consumer Price indices for Denmark, Finland, France, Germany, Italy, Japan, the Netherlands, Norway, Portugal, Spain, Sweden, the UK, and the US covering the period 1895 to 1987 were obtained from Abildgren (2004). The Icelandic consumer price index is constructed for the period by linking several different price indices, with the aim of presenting an index of general prices. 1849–98: Price index based on a basket of 27 selected domestic commodities and imported goods. 1899 to 1938: Price index 1899 to 1912 based on sources from the Laugarnes Leprosery (Reykjavík); 1913 is an estimate; the years 1914 to 1938 are based on price observations of Statistics Iceland made in July 1914 and October each year from 1914 to 1938. 1939 to 1988: Consumer price index excluding housing costs, by Statistics Iceland. Source: Iceland Historical Statistics, 1997.

External trade data for Denmark, Finland, France, Germany, Italy, Japan, the Netherlands, Norway, Portugal, Spain, Sweden, the UK, and the US were collected. Imports are at *cif* value and exports at *fob* value. Data for the Faeroe Islands are included with the data for Denmark. Data for East Germany are included in the data for Germany 1946 to 1988 (Iceland Historical Statistics, 1997)

Terms of trade. Data source: Iceland Historical Statistics, 1997 & the Central Bank of Iceland, 2013.

Official real exchange rate (REER). Data source: Central Bank of Iceland, 2013 (www.cb.is).

Gross Domestic Product. GNP is replaced by the GDP post-1945. GNP is in the

table deflated with a weighted index composed of the consumer price index (2/3) and building cost index (1/3). Iceland Historical Statistics (1997).

Monthly data:

Bilateral exchange rates for the Icelandic króna *vis-à-vis* Belgium, Denmark, Finland, France, Germany, Italy, Japan, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, the UK, and the US were obtained from the Central Bank of Iceland (2013). In September 2002 the following countries adopted the euro: France, the Netherlands, Portugal, Spain, Germany, Belgium, Finland and Italy. From 2002 onwards, the exchange rates for those countries are calculated on basis of the euro exchange rate versus the Icelandic króna and exchange rates of the euro *vis-à-vis* the currencies of the previously listed countries.

External trade data for Belgium, Denmark, Finland, France, Germany, Italy, Japan, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, the UK, and the US were collected. Data for the Faeroe Islands and Greenland are included in the data for Denmark. Imports are at *cif* value and exports at *fob* value (Statistics Iceland, 2013).

Consumer Price indices (CPI) and Harmonized Indices of Consumer Price (HICP) for Belgium, Denmark, Finland, France, Germany, Italy, Japan, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, the UK, the US, and Iceland were collected. Data source: OECD database (2013) & BIS database (2013). HICP replace normal CPI's when available. The Harmonized consumer price index provides a standard measurement for the index and is therefore a better choice as deflator for this kind of survey. HICP data do not exist prior to January 1990. To incorporate HICP into the CPI in order to construct one continuous time-series, relative change in each country's CPI is applied to the starting value of the HICP and calculated backwards. The starting date for HICP measurements varies from country to country. HICP data are available for Denmark, France, Netherlands, Portugal, Sweden, the UK, Finland, and Italy from January 1990, for Spain from January 1992, for Iceland and Germany from January 1995, for Belgium from January 1991, for the US from December 1997, for Japan and Norway from January 1996, and for Switzerland from December 2004. HICP are consumer price indices compiled on the basis of a harmonised coverage and methodology. For further details, *cf.* Harmonized Indices of Consumer Prices. A Short Guide for Users (HICPs), 2004.

II Appendix

Augmented Dickey-Fuller test for Xc_R, including one lag of (1-L)Xc_R (max was 1). Sample size 116 unit-root null hypothesis: $a = 1$, test with constant, model: $(1-L)y = b_0 + (a-1)y(-1) + \dots + e$. 1st-order autocorrelation coeff. for e: 0,011, estimated value of $(a - 1)$: -0,173268, test statistic: $\tau_c(1) = -3,54514$, asymptotic p-value 0,006932.

Augmented Dickey-Fuller regression
OLS, using observations 1897-2012 (T = 116)
Dependent variable: d_Xc_R

	coefficient	std.error	t-ratio	p-value	
const	15,2971	4,44133	3,444	0,0008	***
Xc_R_1	-0,173268	0,04887	-3,545	0,0069	***
d_Xc_R_1	0,231712	0,09174	2,525	0,0129	**

AIC: 884,556 BIC: 892,817 HQC: 887,909

with constant and trend, model: $(1-L)y = b_0 + b_1*t + (a-1)y(-1) + \dots + e$. 1st-order autocorrelation coeff. for e: 0,011. Estimated value of $(a - 1)$: -0,172488. Test statistic: $\tau_{ct}(1) = -3,49982$. Asymptotic p-value 0,03932

Augmented Dickey-Fuller regression
OLS, using observations 1897-2012 (T = 116)
Dependent variable: d_Xc_R

	coefficient	std.error	t-ratio	p-value	
const	15,551	4,687	3,318	0,001	***
Xc_R_1	-0,172	0,049	-3,500	0,039	**
d_Xc_R_1	0,231	0,092	2,495	0,014	**
time	-0,0053	0,030	-0,176	0,860	

AIC: 886,524 BIC: 897,538 HQC: 890,995

Augmented Dickey-Fuller test for l_Xc_R , including one lag of (1-L)l_Xc_R (max was 1). Sample size 116 unit-root null hypothesis: $a = 1$, test with constant, model: $(1-L)y = b_0 + (a-1)y(-1) + \dots + e$. 1st-order autocorrelation coeff. for e: 0,002, estimated value of $(a - 1)$: -0,165752, test statistic: $\tau_c(1) = -3,43032$, asymptotic p-value 0,009997

Augmented Dickey-Fuller regression.
 OLS, using observations 1897-2012 (T = 116)
 Dependent variable: d_l_Xc_R

	coefficient	std.error	t-ratio	p-value
const	0,7383	0,215648	3,424	0,0009 ***
l_Xc_R_1	-0,1657	0,048319	-3,430	0,0100 ***
d_l_Xc_R_1	0,222	0,09210	2,412	0,0175 **

AIC: -182,218 BIC: -173,957 HQC: -178,864

Augmented Dickey-Fuller test for l_Xc_N, including one lag of (1-L)l_Xc_N (max was 1). Sample size 116 unit-root, null hypothesis: $a = 1$, Test with constant, model: $(1-L)y = b_0 + (a-1)y(-1) + \dots + e$. 1st-order autocorrelation coeff. for e: -0,024, estimated value of $(a - 1)$: 0,00599407, test statistic: $\tau_c(1) = 1,11729$, asymptotic p-value 0,9977

Augmented Dickey-Fuller regression
 OLS, using observations 1897-2012 (T = 116)
 Dependent variable: d_l_Xc_N

	coefficient	std.error	t-ratio	p-value
const	-0,0894	0,0489	-1,825	0,0707 *
l_Xc_N_1	0,0059	0,0054	1,117	0,9977
d_l_Xc_N_1	0,347	0,0897	3,876	0,0002 ***

AIC: -110,916 BIC: -102,656 HQC: -107,563

Dickey-Fuller test for d_l_Xc_N. sample size 116 unit-root, null hypothesis: $a = 1$. Test with constant, model: $(1-L)y = b_0 + (a-1)y(-1) + e$. 1st-order autocorrelation coeff. for e: -0,034, estimated value of $(a - 1)$: -0,626694, test statistic: $\tau_c(1) = -7,21607$, p-value 3,547e-009

Dickey-Fuller regression
 OLS, using observations 1897-2012 (T = 116)
 Dependent variable: d_d_l_Xc_N

	coefficient	std.error	t-ratio	p-value
const	-0,0372	0,0147	-2,531	0,0127 **
d_l_Xc_N_1	-0,627	0,0868	-7,216	3,55e-09 ***

AIC: -111,642 BIC: -106,135 HQC: -109,406

Augmented Dickey-Fuller test for l_RelCpi, including 5 lags of (1-L)l_RelCpi (max was 5). Sample size 112 unit-root null hypothesis: $a = 1$, test with constant, model: $(1-L)y = b_0 + (a-1)y(-1) + \dots + e$. 1st-order autocorrelation coeff. for e: 0,029, lagged differences: $F(5, 105) = 18,059$ [0,0000], estimated value of $(a - 1)$: -0,00133539, test statistic: $\tau_c(1) = -0,360434$, asymptotic p-value 0,9134

Augmented Dickey-Fuller regression
 OLS, using observations 1901-2012 (T = 112)
 Dependent variable: d_l_RelCpi

	coefficient	std.error	t-ratio	p-value
const	-0,006860	0,019714	-0,348	0,7286
l_RelCpi_1	-0,001335	0,003704	-0,360	0,9134
d_l_RelCpi_1	0,501489	0,095816	5,234	8,56e-07 ***
d_l_RelCpi_2	0,106433	0,105916	1,005	0,3173
d_l_RelCpi_3	0,190460	0,104932	1,815	0,0724 *
d_l_RelCpi_4	-0,187186	0,10643	-1,759	0,0815 *
d_l_RelCpi_5	0,195784	0,097236	2,013	0,0466 **

AIC: -202,47 BIC: -183,441 HQC: -194,749

Dickey-Fuller test for d_l_RelCpi, sample size 116 unit-root null hypothesis: a = 1. Test with constant, model: $(1-L)y = b_0 + (a-1)y(-1) + e$. 1st-order autocorrelation coeff. for e: -0,142, estimated value of (a - 1): -0,355016, test statistic: tau_c(1) = -4,96875, p-value 5,784e-005

Dickey-Fuller regression
 OLS, using observations 1897-2012 (T = 116)
 Dependent variable: d_d_l_RelCpi

	coefficient	std.error	t-ratio	p-value
const	-0,02097	0,009953	-2,107	0,0373 **
d_l_RelCpi_1	-0,35501	0,071449	-4,969	5,78e-05 ***

AIC: -209,074 BIC: -203,567 HQC: -206,838

Augmented Dickey-Fuller test for Xc_R, including one lag of (1-L)Xc_R (max was 1), sample size 64 unit-root null hypothesis: a = 1. Test with constant, model: $(1-L)y = b_0 + (a-1)y(-1) + \dots + e$. 1st-order autocorrelation coeff. for e: 0,066, estimated value of (a - 1): -0,178154, test statistic: tau_c(1) = -2,80973, asymptotic p-value 0,05686

Augmented Dickey-Fuller regression
 OLS, using observations 1897-1960 (T = 64)
 Dependent variable: d_Xc_R

	coefficient	std.error	t-ratio	p-value
const	15,9700	6,04058	2,644	0,0104 **
Xc_R_1	-0,17815	0,06340	-2,810	0,0569 *
d_Xc_R_1	0,42156	0,164075	2,569	0,0127 **

AIC: 514,199 BIC: 520,675 HQC: 516,75

with constant and trend, model: $(1-L)y = b_0 + b_1*t + (a-1)*y(-1) + \dots + e$.
1st-order autocorrelation coeff. for e: 0,053, estimated value of $(a - 1)$: -0,265034,
test statistic: $\tau_{ct}(1) = -3,07434$, asymptotic p-value 0,1124

Augmented Dickey-Fuller regression
OLS, using observations 1897-1960 (T = 64)
Dependent variable: d_Xc_R

	coefficient	std.error	t-ratio	p-value
const	17,8047	6,1122	2,913	0,0050 ***
Xc_R_1	-0,26503	0,0862	-3,074	0,1124
d_Xc_R_1	0,45243	0,16388	2,761	0,0076 ***
time	0,1785	0,12133	1,471	0,1464

AIC: 513,93 BIC: 522,566 HQC: 517,332

Augmented Dickey-Fuller test for l_Xc_R, including one lag of $(1-L)l_Xc_R$
(max was 1). Sample size 64 unit-root null hypothesis: $a = 1$, test with constant,
model: $(1-L)y = b_0 + (a-1)*y(-1) + \dots + e$. 1st-order autocorrelation coeff. for
e: 0,032, estimated value of $(a - 1)$: -0,159082, test statistic: $\tau_c(1) = -2,61791$,
asymptotic p-value 0,08926

Augmented Dickey-Fuller regression
OLS, using observations 1897-1960 (T = 64)
Dependent variable: d_l_Xc_R

	coefficient	std.error	t-ratio	p-value
const	0,70943	0,2727	2,601	0,0116 **
l_Xc_R_1	-0,15908	0,0607	-2,618	0,0893 *
d_l_Xc_R_1	0,40012	0,1653	2,421	0,0185 **

AIC: -79,6157 BIC: -73,1391 HQC: -77,0643

Dickey-Fuller test for l_Xc_N, sample size 65 unit-root null hypothesis: $a = 1$,
test with constant, model: $(1-L)y = b_0 + (a-1)*y(-1) + e$. 1st-order autocorrelation
coeff. for e: 0,227, estimated value of $(a - 1)$: -0,0259043, test statistic: $\tau_c(1) =$
-0,413977, p-value 0,9

Dickey-Fuller regression
OLS, using observations 1896-1960 (T = 65)
Dependent variable: d_l_Xc_N

	coefficient	std.error	t-ratio	p-value
const	0,2565	0,65496	0,3917	0,6966
l_Xc_N_1	-0,0259	0,06257	-0,4140	0,9000

AIC: -58,2537 BIC: -53,9049 HQC: -56,5378

Dickey-Fuller test for d_l_Xc_N, sample size 64 unit-root null hypothesis: $a = 1$, test with constant, model: $(1-L)y = b_0 + (a-1)*y(-1) + e$. 1st-order autocorrelation coeff. for e: 0,013, estimated value of $(a - 1)$: -0,78259, test statistic: $\tau_c(1) = -4,72$, p-value 0,0001

Dickey-Fuller regression
 OLS, using observations 1897-1960 (T = 64)
 Dependent variable: d_d_l_Xc_N

	coefficient	std.error	t-ratio	p-value
const	-0,01426	0,018951	-0,753	0,4545
d_l_Xc_N_1	-0,78259	0,165803	-4,720	0,0001 ***

AIC: -57,8941 BIC: -53,5764 HQC: -56,1932

Augmented Dickey-Fuller test for l_RelCpi, including one lag of $(1-L)l_RelCpi$ (max was 1), sample size 64 unit-root null hypothesis: $a = 1$, test with constant, model: $(1-L)y = b_0 + (a-1)*y(-1) + \dots + e$. 1st-order autocorrelation coeff. for e: -0,073, estimated value of $(a - 1)$: -0,0275863, test statistic: $\tau_c(1) = -0,92002$, asymptotic p-value 0,7825

Augmented Dickey-Fuller regression
 OLS, using observations 1897-1960 (T = 64)
 Dependent variable: d_l_RelCpi

	coefficient	std.error	t-ratio	p-value
const	0,1559	0,18005	0,8664	0,3897
l_RelCpi_1	-0,0275	0,02998	-0,920	0,7825
d_l_RelCpi_1	0,4336	0,11932	3,634	0,0006 ***

AIC: -102,6 BIC: -96,1233 HQC: -100,048

Dickey-Fuller test for d_l_RelCpi, sample size 64 unit-root null hypothesis: $a = 1$, test with constant, model: $(1-L)y = b_0 + (a-1)*y(-1) + e$. 1st-order autocorrelation coeff. for e: -0,055, estimated value of $(a - 1)$: -0,590563, test statistic: $\tau_c(1) = -5,08045$, p-value 7,241e-005

Dickey-Fuller regression
 OLS, using observations 1897-1960 (T = 64)
 Dependent variable: d_d_l_RelCpi

	coefficient	std.error	t-ratio	p-value
const	-0,0092	0,0133	-0,6903	0,4926
d_l_RelCpi_1	-0,5905	0,1162	-5,080	7,24e-05 ***

AIC: -103,718 BIC: -99,4002 HQC: -102,017

Augmented Dickey-Fuller test for Xc_R_1960_2012
including 3 lags of (1-L)Xc_R_1960_2012 (max was 3), sample size 49 unit-root null hypothesis: $a = 1$, test with constant, model: $(1-L)y = b_0 + (a-1)*y(-1) + \dots + e$. 1st-order autocorrelation coeff. for e: -0,016, lagged differences: $F(3, 44) = 1,433$ [0,2459], estimated value of $(a - 1)$: -0,482749, test statistic: $\tau_c(1) = -3,13359$, asymptotic p-value 0,02419

Augmented Dickey-Fuller regression
OLS, using observations 1964-2012 (T = 49)
Dependent variable: d_Xc_R_1960_2012

	coefficient	std.error	t-ratio	p-value	
const	40,658	13,084	3,107	0,0033	***
Xc_R_1960_2012_1	-0,4827	0,1540	3,134	0,0242	**
d_Xc_R_1960_20~_1	0,2957	0,1649	1,793	0,0798	*
d_Xc_R_1960_20~_2	0,1179	0,1574	0,748	0,4579	
d_Xc_R_1960_20~_3	0,2659	0,1592	1,670	0,1020	
AIC: 329,861 BIC: 339,32 HQC: 333,45					

Dickey-Fuller test for Xc_R_1960_2012, sample size 52 unit-root null hypothesis: $a = 1$, with constant and trend, model: $(1-L)y = b_0 + b_1*t + (a-1)*y(-1) + e$. 1st-order autocorrelation coeff. for e: 0,085, estimated value of $(a - 1)$: -0,279732, test statistic: $\tau_{ct}(1) = -2,85408$, p-value 0,1856

Dickey-Fuller regression
OLS, using observations 1961-2012 (T = 52)
Dependent variable: d_Xc_R_1960_2012

	coefficient	std.error	t-ratio	p-value	
const	31,776	10,6421	2,986	0,0044	***
Xc_R_1960_2012_1	-0,2797	0,09801	-2,854	0,1856	
time	-0,0915	0,06099	-1,501	0,1398	
AIC: 345,664 BIC: 351,518 HQC: 347,908					

Augmented Dickey-Fuller test for l_Xc_R_1960_2012, including 3 lags of (1-L)l_Xc_R_1960_2012 (max was 3), sample size 49 unit-root null hypothesis: $a = 1$, test with constant, model: $(1-L)y = b_0 + (a-1)*y(-1) + \dots + e$. 1st-order autocorrelation coeff. for e: -0,010, lagged differences: $F(3, 44) = 1,573$ [0,2094], estimated value of $(a - 1)$: -0,46579, test statistic: $\tau_c(1) = -3,06756$, asymptotic p-value 0,02907

Augmented Dickey-Fuller regression
 OLS, using observations 1964-2012 (T = 49)
 Dependent variable: d_l_Xc_R_1960_2012

	coefficient	std.error	t-ratio	p-value
const	2,0621	0,6733	3,062	0,0037 ***
l_Xc_R_1960_20~_1	-0,465	0,1518	-3,068	0,0291 **
d_l_Xc_R_1960_~_1	0,3162	0,1644	1,923	0,0610 *
d_l_Xc_R_1960_~_2	0,1169	0,1577	0,740	0,4627
d_l_Xc_R_1960_~_3	0,2797	0,1637	1,708	0,0947 *

AIC: -103,173 BIC: -93,7141 HQC: -99,5844

Dickey-Fuller test for l_Xc_N_1960_2012, sample size 52 unit-root null hypothesis: $a = 1$, test with constant, model: $(1-L)y = b_0 + (a-1)y(-1) + e$. 1st-order autocorrelation coeff. for e: 0,459, estimated value of $(a - 1)$: -0,0141904, test statistic: $\tau_c(1) = -1,459$, p-value 0,5463

Dickey-Fuller regression
 OLS, using observations 1961-2012 (T = 52)
 Dependent variable: d_l_Xc_N_1960_2012

	coefficient	std.error	t-ratio	p-value
const	-0,0288	0,0619	-0,466	0,6434
l_Xc_N_1960_20~_1	-0,0141	0,0097	-1,459	0,5463

AIC: -48,0732 BIC: -44,1707 HQC: -46,5771

Dickey-Fuller test for d_l_Xc_N_1960_2012, sample size 51 unit-root null hypothesis: $a = 1$, test with constant, model: $(1-L)y = b_0 + (a-1)y(-1) + e$. 1st-order autocorrelation coeff. for e: -0,027, estimated value of $(a - 1)$: -0,524971, test statistic: $\tau_c(1) = -4,15546$, p-value 0,001864

Dickey-Fuller regression
 OLS, using observations 1962-2012 (T = 51)
 Dependent variable: d_d_l_Xc_N_1960_2012

	coefficient	std.error	t-ratio	p-value
const	-0,0590	0,0239	-2,460	0,0174 **
d_l_Xc_N_1960_~_1	-0,5249	0,1263	-4,155	0,0019 ***

AIC: -56,8859 BIC: -53,0222 HQC: -55,4094

Dickey-Fuller test for l_RelCpi_1960_2012, sample size 52 unit-root null hypothesis: $a = 1$, test with constant, model: $(1-L)y = b_0 + (a-1)y(-1) + e$. 1st-order autocorrelation coeff. for e: 0,753, estimated value of $(a - 1)$: -0,0179279, test statistic: $\tau_c(1) = -2,38101$, p-value 0,1519

Dickey-Fuller regression
 OLS, using observations 1961-2012 (T = 52)
 Dependent variable: d_l_RelCpi_1960_2012

	coefficient	std.error	t-ratio	p-value
const	-0,0842	0,01996	-4,219	0,0001 ***
l_RelCpi_1960_~_1	-0,0179	0,00753	-2,381	0,1519

AIC: -74,7991 BIC: -70,8966 HQC: -73,3029

Dickey-Fuller test for d_l_RelCpi_1960_2012, sample size 51 unit-root null hypothesis: $a = 1$, test with constant, model: $(1-L)y = b_0 + (a-1)*y(-1) + e$. 1st-order autocorrelation coeff. for e: -0,145, estimated value of $(a - 1)$: -0,219185, test statistic: $\tau_c(1) = -2,42779$, p-value 0,1394

Dickey-Fuller regression
 OLS, using observations 1962-2012 (T = 51)
 Dependent variable: d_d_l_RelCpi_1960_2012

	coefficient	std.error	t-ratio	p-value
const	-0,0238	0,01496	-1,588	0,1186
d_l_RelCpi_196~_1	-0,2192	0,09028	-2,428	0,1394

AIC: -114,114 BIC: -110,25 HQC: -112,637

Augmented Dickey-Fuller test for Xc_R, including one lag of $(1-L)Xc_R$ (max was 1), sample size 298 unit-root null hypothesis: $a = 1$

test with constant, model: $(1-L)y = b_0 + (a-1)*y(-1) + \dots + e$. 1st-order autocorrelation coeff. for e: 0,041, estimated value of $(a - 1)$: -0,025077, test statistic: $\tau_c(1) = -2,44929$, asymptotic p-value 0,1283

Augmented Dickey-Fuller regression
 OLS, using observations 1988:03-2012:12 (T = 298)
 Dependent variable: d_Xc_R

	coefficient	std.error	t-ratio	p-value
const	2,1594	0,9374	2,304	0,0219 **
Xc_R_1	-0,0250	0,0102	-2,449	0,1283
d_Xc_R_1	0,2811	0,0556	5,058	7,46e-07 ***

AIC: 1251,15 BIC: 1262,24 HQC: 1255,59

with constant and trend, model: $(1-L)y = b_0 + b_1*t + (a-1)*y(-1) + \dots + e$. 1st-order autocorrelation coeff. for e: 0,038, estimated value of $(a - 1)$: -0,0472946, test statistic: $\tau_{ct}(1) = -3,25189$, asymptotic p-value 0,07448

Augmented Dickey-Fuller regression
 OLS, using observations 1988:03-2012:12 (T = 298)
 Dependent variable: d_Xc_R

	coefficient	std.error	t-ratio	p-value
const	4,7879	1,5424	3,104	0,0021 ***
Xc_R_1	-0,0472	0,0145	-3,252	0,0745 *
d_Xc_R_1	0,2927	0,0555	5,272	2,62e-07 ***
time	-0,004	0,0019	-2,138	0,0333 **

AIC: 1248,55 BIC: 1263,34 HQC: 1254,47

Augmented Dickey-Fuller test for l_Xc_R, including one lag of (1-L)l_Xc_R (max was 1), sample size 298 unit-root null hypothesis: $a = 1$, test with constant, model: $(1-L)y = b_0 + (a-1)y(-1) + \dots + e$. 1st-order autocorrelation coeff. for e: 0,045, estimated value of $(a - 1)$: -0,0227047, test statistic: $\tau_c(1) = -2,2185$, asymptotic p-value 0,1997

Augmented Dickey-Fuller regression
 OLS, using observations 1988:03-2012:12 (T = 298)
 Dependent variable: d_l_Xc_R

	coefficient	std.error	t-ratio	p-value
const	0,1009	0,04609	2,190	0,0293 **
l_Xc_R_1	-0,0227	0,01023	-2,218	0,1997
d_l_Xc_R_1	0,2911	0,05563	5,233	3,17e-07 ***

AIC: -1400,56 BIC: -1389,47 HQC: -1396,12

Augmented Dickey-Fuller test for l_Xc_N, including one lag of (1-L)l_Xc_N (max was 1), sample size 298 unit-root null hypothesis: $a = 1$, test with constant, model: $(1-L)y = b_0 + (a-1)y(-1) + \dots + e$. 1st-order autocorrelation coeff. for e: 0,045, estimated value of $(a - 1)$: -0,00648686, test statistic: $\tau_c(1) = -1,41897$, asymptotic p-value 0,5746

Augmented Dickey-Fuller regression
 OLS, using observations 1988:03-2012:12 (T = 298)
 Dependent variable: d_l_Xc_N

	coefficient	std. error	t-ratio	p-value
const	0,02649	0,02064	1,283	0,2005
l_Xc_N_1	-0,00649	0,00457	-1,419	0,5746
d_l_Xc_N_1	0,37902	0,05372	7,054	1,24e-011 ***

AIC: -1399,25 BIC: -1388,16 HQC: -1394,81

Augmented Dickey-Fuller test for d_l_Xc_N, including one lag of (1-L)d_l_Xc_N (max was 1), sample size 297 unit-root null hypothesis: $a = 1$, test with constant, model: $(1-L)y = b_0 + (a-1)y(-1) + \dots + e$. 1st-order autocorrelation coeff. for e: 0,009, estimated value of $(a - 1)$: -0,690755, test statistic: $\tau_c(1) = -10,8036$, asymptotic p-value 8,366e-022

Augmented Dickey-Fuller regression
OLS, using observations 1988:04-2012:12 (T = 297)
Dependent variable: d_d_l_Xc_N

	coefficient	std.error	t-ratio	p-value
const	-0,0028	0,00135	2,107	0,0360 **
d_l_Xc_N_1	-0,6907	0,06394	-10,80	8,37e-022 ***
d_d_l_Xc_N_1	0,1129	0,05732	1,969	0,0499 **

AIC: -1401,97 BIC: -1390,89 HQC: -1397,53

Dickey-Fuller test for l_RelCpi, sample size 299 unit-root null hypothesis: $a = 1$, test with constant, model: $(1-L)y = b_0 + (a-1)y(-1) + e$. 1st-order autocorrelation coeff. for e: 0,445, estimated value of $(a - 1)$: -0,00388599, test statistic: $\tau_c(1) = -1,6364$, p-value 0,4627

Dickey-Fuller regression
OLS, using observations 1988:02-2012:12 (T = 299)
Dependent variable: d_l_RelCpi

	coefficient	std.error	t-ratio	p-value
const	-0,0026	0,000415	-6,285	1,17e-09 ***
l_RelCpi_1	-0,0039	0,002375	-1,636	0,4627

AIC: -2102,74 BIC: -2095,34 HQC: -2099,78

Dickey-Fuller test for d_l_RelCpi, sample size 298 unit-root null hypothesis: $a = 1$, test with constant, model: $(1-L)y = b_0 + (a-1)y(-1) + e$. 1st-order autocorrelation coeff. for e: -0,074, estimated value of $(a - 1)$: -0,551834, test statistic: $\tau_c(1) = -10,6151$, p-value 1,441e-018

Dickey-Fuller regression
OLS, using observations 1988:03-2012:12 (T = 298)
Dependent variable: d_d_l_RelCpi

	coefficient	std.error	t-ratio	p-value
const	-0,0014	0,00037	-3,623	0,0003 ***
d_l_RelCpi_1	-0,5518	0,05198	-10,62	1,44e-018 ***

AIC: -2158,82 BIC: -2151,42 HQC: -2155,86

OLS, using observations 1897–2012 ($T = 116$)

Dependent variable: Xc_R

	Coefficient	Std. Error	t-ratio	p-value
const	15,2971	4,4413	3,4443	0,0008
Xc_R_1	1,0584	0,0915	11,5649	0,0000
Xc_R_2	−0,2317	0,0917	−2,5255	0,0129
Mean dependent var	88,43992	S.D. dependent var	21,48312	
Sum squared resid	13219,81	S.E. of regression	10,81617	
R^2	0,750924	Adjusted R^2	0,746515	
$F(2, 113)$	170,3380	P-value(F)	7,81e−35	
Log-likelihood	−439,2780	Akaike criterion	884,5560	
Schwarz criterion	892,8168	Hannan–Quinn	887,9094	
$\hat{\rho}$	0,010775	Durbin's h	0,603017	

LM test for autocorrelation up to order 1 –

Null hypothesis: no autocorrelation

Test statistic: LMF = 0,241768

with p-value = $P(F(1, 112) > 0,241768) = 0,623894$

LM test for autocorrelation up to order 2 –

Null hypothesis: no autocorrelation

Test statistic: LMF = 0,16029

with p-value = $P(F(2, 111) > 0,16029) = 0,852093$

LM test for autocorrelation up to order 3 –

Null hypothesis: no autocorrelation

Test statistic: LMF = 0,194025

with p-value = $P(F(3, 110) > 0,194025) = 0,900275$

LM test for autocorrelation up to order 4 –

Null hypothesis: no autocorrelation

Test statistic: LMF = 0,498338

with p-value = $P(F(4, 109) > 0,498338) = 0,73698$

White's test for heteroskedasticity –

Null hypothesis: heteroskedasticity not present

Test statistic: LM = 25,2318

with p-value = $P(\chi^2(5) > 25,2318) = 0,00012568$

White's test for heteroskedasticity (squares only) –

Null hypothesis: heteroskedasticity not present

Test statistic: LM = 24,6408

with p-value = $P(\chi^2(4) > 24,6408) = 5,94063e-005$

Test for normality of residual –

Null hypothesis: error is normally distributed

Test statistic: $\chi^2(2) = 73,7181$

with p-value = 9,82452e-017

OLS, using observations 1897–2012 ($T = 116$)

Dependent variable: Xc_R

	Coefficient	Std. Error	<i>t</i> -ratio	p-value
const	15,5511	4,68723	3,3178	0,0012
time	−0,00534073	0,0302825	−0,1764	0,8603
Xc_R_1	1,05802	0,0919486	11,5067	0,0000
Xc_R_2	−0,230509	0,0923979	−2,4947	0,0141
Mean dependent var	88,43992	S.D. dependent var	21,48312	
Sum squared resid	13216,14	S.E. of regression	10,86284	
R^2	0,750993	Adjusted R^2	0,744323	
$F(3, 112)$	112,5954	P-value(F)	1,14e−33	
Log-likelihood	−439,2619	Akaike criterion	886,5238	
Schwarz criterion	897,5382	Hannan–Quinn	890,9950	
$\hat{\rho}$	0,010908	Durbin's h	0,702478	

LM test for autocorrelation up to order 1 –

Null hypothesis: no autocorrelation

Test statistic: LMF = 0,248408

with p-value = $P(F(1, 111) > 0,248408) = 0,619185$

LM test for autocorrelation up to order 2 –

Null hypothesis: no autocorrelation

Test statistic: LMF = 0,166767

with p-value = $P(F(2, 110) > 0,166767) = 0,84661$

LM test for autocorrelation up to order 3 –

Null hypothesis: no autocorrelation

Test statistic: LMF = 0,17564

with p-value = $P(F(3, 109) > 0,17564) = 0,912687$

LM test for autocorrelation up to order 4 –

Null hypothesis: no autocorrelation

Test statistic: LMF = 0,518602

with p-value = $P(F(4, 108) > 0,518602) = 0,722216$

White's test for heteroskedasticity –

Null hypothesis: heteroskedasticity not present

Test statistic: LM = 28,4342

with p-value = $P(\chi^2(9) > 28,4342) = 0,000806822$

White's test for heteroskedasticity (squares only) –

Null hypothesis: heteroskedasticity not present

Test statistic: LM = 24,9801

with p-value = $P(\chi^2(6) > 24,9801) = 0,000344368$

Test for normality of residual –

Null hypothesis: error is normally distributed

Test statistic: $\chi^2(2) = 72,7118$

with p-value = 1,62494e-016

OLS, using observations 1897–2012 ($T = 116$)

Dependent variable: l_Xc_R

	Coefficient	Std. Error	<i>t</i> -ratio	p-value
const	0,738339	0,215648	3,4238	0,0009
l_Xc_R_1	1,05639	0,0917358	11,5156	0,0000
l_Xc_R_2	−0,222144	0,0921041	−2,4119	0,0175
Mean dependent var	4,456912	S.D. dependent var		0,219033
Sum squared resid	1,340639	S.E. of regression		0,108922
R^2	0,757007	Adjusted R^2		0,752706
$F(2, 113)$	176,0167	P-value(F)		1,93e−35
Log-likelihood	94,10888	Akaike criterion		−182,2178
Schwarz criterion	−173,9570	Hannan–Quinn		−178,8644
$\hat{\rho}$	0,002317	Durbin's h		0,138442

LM test for autocorrelation up to order 1 –

Null hypothesis: no autocorrelation

Test statistic: LMF = 0,0121513

with p-value = $P(F(1, 112) > 0,0121513) = 0,912422$

LM test for autocorrelation up to order 2 –

Null hypothesis: no autocorrelation

Test statistic: LMF = 0,0141038

with p-value = $P(F(2, 111) > 0,0141038) = 0,985997$

LM test for autocorrelation up to order 3 –

Null hypothesis: no autocorrelation

Test statistic: LMF = 0,0650737

with p-value = $P(F(3, 110) > 0,0650737) = 0,978243$

LM test for autocorrelation up to order 4 –

Null hypothesis: no autocorrelation

Test statistic: LMF = 0,408025

with p-value = $P(F(4, 109) > 0,408025) = 0,802528$

White's test for heteroskedasticity –

Null hypothesis: heteroskedasticity not present

Test statistic: LM = 17,875

with p-value = $P(\chi^2(5) > 17,875) = 0,00310719$

White's test for heteroskedasticity (squares only) –

Null hypothesis: heteroskedasticity not present

Test statistic: LM = 17,1959

with p-value = $P(\chi^2(4) > 17,1959) = 0,00177069$

Test for normality of residual –

Null hypothesis: error is normally distributed

Test statistic: $\chi^2(2) = 49,509$

with p-value = 1,77522e-011

OLS, using observations 1897–1960 ($T = 64$)

Dependent variable: Xc_R

	Coefficient	Std. Error	<i>t</i> -ratio	p-value
const	15,9700	6,04058	2,6438	0,0104
Xc_R_1	1,24341	0,159570	7,7922	0,0000
Xc_R_2	−0,421560	0,164075	−2,5693	0,0127
Mean dependent var	92,40288	S.D. dependent var	27,06588	
Sum squared resid	10526,06	S.E. of regression	13,13615	
R^2	0,771923	Adjusted R^2	0,764445	
$F(2, 61)$	103,2269	P-value(F)	2,64e−20	
Log-likelihood	−254,0993	Akaike criterion	514,1986	
Schwarz criterion	520,6753	Hannan–Quinn	516,7501	
$\hat{\rho}$	0,065507	Durbin–Watson	1,529369	

LM test for autocorrelation up to order 1 –

Null hypothesis: no autocorrelation

Test statistic: LMF = 1,01045

with p-value = $P(F(1, 60) > 1,01045) = 0,318832$

LM test for autocorrelation up to order 2 –

Null hypothesis: no autocorrelation

Test statistic: LMF = 0,59232

with p-value = $P(F(2, 59) > 0,59232) = 0,556298$

LM test for autocorrelation up to order 3 –

Null hypothesis: no autocorrelation

Test statistic: LMF = 0,482729

with p-value = $P(F(3, 58) > 0,482729) = 0,695575$

LM test for autocorrelation up to order 4 –

Null hypothesis: no autocorrelation

Test statistic: LMF = 0,50306

with p-value = $P(F(4, 57) > 0,50306) = 0,733583$

White's test for heteroskedasticity –

Null hypothesis: heteroskedasticity not present

Test statistic: LM = 13,5652

with p-value = $P(\chi^2(5) > 13,5652) = 0,0186207$

White's test for heteroskedasticity (squares only) –

Null hypothesis: heteroskedasticity not present

Test statistic: LM = 13,3138

with p-value = $P(\chi^2(4) > 13,3138) = 0,00983987$

Test for normality of residual –

Null hypothesis: error is normally distributed

Test statistic: $\chi^2(2) = 44,2471$

with p-value = 2,46531e-010

OLS, using observations 1897–1960 ($T = 64$)

Dependent variable: Xc_R

	Coefficient	Std. Error	<i>t</i> -ratio	p-value
const	17,8047	6,11229	2,9129	0,0050
time	0,178521	0,121336	1,4713	0,1464
Xc_R_1	1,18740	0,162587	7,3032	0,0000
Xc_R_2	−0,452437	0,163880	−2,7608	0,0076
Mean dependent var	92,40288	S.D. dependent var	27,06588	
Sum squared resid	10159,52	S.E. of regression	13,01251	
R^2	0,779865	Adjusted R^2	0,768859	
$F(3, 60)$	70,85346	P-value(F)	1,06e−19	
Log-likelihood	−252,9651	Akaike criterion	513,9303	
Schwarz criterion	522,5658	Hannan–Quinn	517,3323	
$\hat{\rho}$	0,053213	Durbin–Watson	1,520910	

LM test for autocorrelation up to order 1 –

Null hypothesis: no autocorrelation

Test statistic: LMF = 0,528047

with p-value = $P(F(1, 59) > 0,528047) = 0,470302$

LM test for autocorrelation up to order 2 –

Null hypothesis: no autocorrelation

Test statistic: LMF = 0,443305

with p-value = $P(F(2, 58) > 0,443305) = 0,644068$

LM test for autocorrelation up to order 3 –

Null hypothesis: no autocorrelation

Test statistic: LMF = 0,409194

with p-value = $P(F(3, 57) > 0,409194) = 0,746989$

LM test for autocorrelation up to order 4 –

Null hypothesis: no autocorrelation

Test statistic: LMF = 0,378875

with p-value = $P(F(4, 56) > 0,378875) = 0,822779$

White's test for heteroskedasticity –

Null hypothesis: heteroskedasticity not present

Test statistic: LM = 19,6845

with p-value = $P(\chi^2(9) > 19,6845) = 0,0199628$

White's test for heteroskedasticity (squares only) –

Null hypothesis: heteroskedasticity not present

Test statistic: LM = 13,0133

with p-value = $P(\chi^2(6) > 13,0133) = 0,0428252$

Test for normality of residual –

Null hypothesis: error is normally distributed

Test statistic: $\chi^2(2) = 44,9109$

with p-value = 1,76895e-010

OLS, using observations 1897–1960 ($T = 64$)

Dependent variable: l_Xc_R

	Coefficient	Std. Error	t-ratio	p-value
const	0,709431	0,272753	2,6010	0,0116
l_Xc_R_1	1,24104	0,161581	7,6806	0,0000
l_Xc_R_2	-0,400127	0,165307	-2,4205	0,0185
Mean dependent var	4,487903	S.D. dependent var	0,271622	
Sum squared resid	0,983399	S.E. of regression	0,126970	
R^2	0,788428	Adjusted R^2	0,781491	
$F(2, 61)$	113,6588	P-value(F)	2,67e-21	
Log-likelihood	42,80787	Akaike criterion	-79,61574	
Schwarz criterion	-73,13909	Hannan–Quinn	-77,06426	
$\hat{\rho}$	0,031547	Durbin–Watson	1,557157	

LM test for autocorrelation up to order 1 –

Null hypothesis: no autocorrelation

Test statistic: LMF = 0,245716

with p-value = $P(F(1, 60) > 0,245716) = 0,621918$

LM test for autocorrelation up to order 2 –

Null hypothesis: no autocorrelation

Test statistic: LMF = 0,121415

with p-value = $P(F(2, 59) > 0,121415) = 0,885887$

LM test for autocorrelation up to order 3 –

Null hypothesis: no autocorrelation

Test statistic: LMF = 0,101124

with p-value = $P(F(3, 58) > 0,101124) = 0,959053$

LM test for autocorrelation up to order 4 –

Null hypothesis: no autocorrelation

Test statistic: LMF = 0,191

with p-value = $P(F(4, 57) > 0,191) = 0,942147$

White's test for heteroskedasticity –

Null hypothesis: heteroskedasticity not present

Test statistic: LM = 10,3855

with p-value = $P(\chi^2(5) > 10,3855) = 0,0650219$

White's test for heteroskedasticity (squares only) –

Null hypothesis: heteroskedasticity not present

Test statistic: LM = 10,2512

with p-value = $P(\chi^2(4) > 10,2512) = 0,0364019$

Test for normality of residual –

Null hypothesis: error is normally distributed

Test statistic: $\chi^2(2) = 37,3186$

with p-value = 7,87714e-009

OLS, using observations 1962–2012 ($T = 51$)

Dependent variable: Xc_R_1960_2012

	Coefficient	Std. Error	<i>t</i> -ratio	p-value
const	27,1306	9,22864	2,9398	0,0050
Xc_R_1960_2012_1	0,850368	0,142144	5,9824	0,0000
Xc_R_1960_2012_2	−0,174376	0,144981	−1,2028	0,2350
Mean dependent var	83,82926	S.D. dependent var		9,479373
Sum squared resid	2104,277	S.E. of regression		6,621110
R^2	0,531647	Adjusted R^2		0,512132
$F(2, 48)$	27,24335	P-value(F)		1,24e−08
Log-likelihood	−167,2234	Akaike criterion		340,4467
Schwarz criterion	346,2422	Hannan–Quinn		342,6613
$\hat{\rho}$	−0,014845	Durbin–Watson		2,010122

LM test for autocorrelation up to order 1 –

Null hypothesis: no autocorrelation

Test statistic: LMF = 0,277671

with p-value = $P(F(1, 47) > 0,277671) = 0,60071$

LM test for autocorrelation up to order 2 –

Null hypothesis: no autocorrelation

Test statistic: LMF = 0,446407

with p-value = $P(F(2, 46) > 0,446407) = 0,642666$

LM test for autocorrelation up to order 3 –

Null hypothesis: no autocorrelation

Test statistic: LMF = 1,09831

with p-value = $P(F(3, 45) > 1,09831) = 0,359695$

LM test for autocorrelation up to order 4 –

Null hypothesis: no autocorrelation

Test statistic: LMF = 1,20654

with p-value = $P(F(4, 44) > 1,20654) = 0,32158$

White's test for heteroskedasticity (squares only) –

Null hypothesis: heteroskedasticity not present

Test statistic: LM = 1,11055

with p-value = $P(\chi^2(4) > 1,11055) = 0,892595$

White's test for heteroskedasticity –

Null hypothesis: heteroskedasticity not present

Test statistic: LM = 8,95846

with p-value = $P(\chi^2(5) > 8,95846) = 0,110733$

Test for normality of residual –

Null hypothesis: error is normally distributed

Test statistic: $\chi^2(2) = 1,74447$

with p-value = 0,418016

OLS, using observations 1961–2012 ($T = 52$)

Dependent variable: Xc_R_1960_2012

	Coefficient	Std. Error	<i>t</i> -ratio	p-value
const	31,7764	10,6421	2,9859	0,0044
time	−0,0915501	0,0609988	−1,5008	0,1398
Xc_R_1960_2012_1	0,720268	0,0980111	7,3488	0,0000
Mean dependent var	83,56243	S.D. dependent var	9,581168	
Sum squared resid	2090,938	S.E. of regression	6,532396	
R^2	0,553384	Adjusted R^2	0,535155	
$F(2, 49)$	30,35701	P-value(F)	2,65e−09	
Log-likelihood	−169,8320	Akaike criterion	345,6641	
Schwarz criterion	351,5178	Hannan–Quinn	347,9082	
$\hat{\rho}$	0,084836	Durbin's h	0,848284	

LM test for autocorrelation up to order 1 –

Null hypothesis: no autocorrelation

Test statistic: LMF = 0,644903

with p-value = $P(F(1, 48) > 0,644903) = 0,4259$

LM test for autocorrelation up to order 2 –

Null hypothesis: no autocorrelation

Test statistic: LMF = 0,422911

with p-value = $P(F(2, 47) > 0,422911) = 0,657605$

LM test for autocorrelation up to order 3 –

Null hypothesis: no autocorrelation

Test statistic: LMF = 0,321171

with p-value = $P(F(3, 46) > 0,321171) = 0,810007$

LM test for autocorrelation up to order 4 –

Null hypothesis: no autocorrelation

Test statistic: LMF = 0,477526

with p-value = $P(F(4, 45) > 0,477526) = 0,752004$

White's test for heteroskedasticity –

Null hypothesis: heteroskedasticity not present

Test statistic: LM = 9,189

with p-value = $P(\chi^2(5) > 9,189) = 0,101759$

White's test for heteroskedasticity (squares only) –

Null hypothesis: heteroskedasticity not present

Test statistic: LM = 8,13327

with p-value = $P(\chi^2(4) > 8,13327) = 0,0868165$

Test for normality of residual –

Null hypothesis: error is normally distributed

Test statistic: $\chi^2(2) = 2,06003$

with p-value = 0,357002

OLS, using observations 1962–2012 ($T = 51$)

Dependent variable: l_Xc_R_1960_2012

	Coefficient	Std. Error	<i>t</i> -ratio	p-value
const	1,34632	0,466962	2,8832	0,0059
l_Xc_R_1960_2012_1	0,890284	0,141582	6,2881	0,0000
l_Xc_R_1960_2012_2	−0,194835	0,145016	−1,3435	0,1854
Mean dependent var	4,422121	S.D. dependent var		0,118509
Sum squared resid	0,306502	S.E. of regression		0,079909
R^2	0,563523	Adjusted R^2		0,545336
$F(2, 48)$	30,98569	P-value(F)		2,29e−09
Log-likelihood	58,05022	Akaike criterion		−110,1004
Schwarz criterion	−104,3050	Hannan–Quinn		−107,8858
$\hat{\rho}$	−0,015092	Durbin–Watson		2,011493

LM test for autocorrelation up to order 1 –

Null hypothesis: no autocorrelation

Test statistic: LMF = 0,244237

with p-value = $P(F(1, 47) > 0,244237) = 0,623465$

LM test for autocorrelation up to order 2 –

Null hypothesis: no autocorrelation

Test statistic: LMF = 0,456462

with p-value = $P(F(2, 46) > 0,456462) = 0,636359$

LM test for autocorrelation up to order 3 –

Null hypothesis: no autocorrelation

Test statistic: LMF = 1,20547

with p-value = $P(F(3, 45) > 1,20547) = 0,318629$

LM test for autocorrelation up to order 4 –

Null hypothesis: no autocorrelation

Test statistic: LMF = 1,25688

with p-value = $P(F(4, 44) > 1,25688) = 0,301277$

White's test for heteroskedasticity –

Null hypothesis: heteroskedasticity not present

Test statistic: LM = 9,80269

with p-value = $P(\chi^2(5) > 9,80269) = 0,081023$

White's test for heteroskedasticity (squares only) –

Null hypothesis: heteroskedasticity not present

Test statistic: LM = 0,39525

with p-value = $P(\chi^2(4) > 0,39525) = 0,982864$

Test for normality of residual –

Null hypothesis: error is normally distributed

Test statistic: $\chi^2(2) = 4,26947$

with p-value = 0,118276

OLS, using observations 1988:09–2012:12 ($T = 292$)

Dependent variable: Xc_R

	Coefficient	Std. Error	<i>t</i> -ratio	p-value
const	1,80308	0,927708	1,9436	0,0529
Xc_R_1	1,32112	0,0575423	22,9592	0,0000
Xc_R_2	−0,486482	0,0952540	−5,1072	0,0000
Xc_R_3	0,192453	0,0991324	1,9414	0,0532
Xc_R_4	−0,118765	0,0993243	−1,1957	0,2328
Xc_R_5	0,0920799	0,0982011	0,9377	0,3492
Xc_R_6	−0,112666	0,0956860	−1,1775	0,2400
Xc_R_7	0,327422	0,0906987	3,6100	0,0004
Xc_R_8	−0,236149	0,0553814	−4,2640	0,0000
Mean dependent var	90,27052	S.D. dependent var	10,88166	
Sum squared resid	946,8075	S.E. of regression	1,829101	
R^2	0,972522	Adjusted R^2	0,971746	
$F(8, 283)$	1252,037	P-value(F)	5,9e−216	
Log-likelihood	−586,0760	Akaike criterion	1190,152	
Schwarz criterion	1223,243	Hannan–Quinn	1203,407	
$\hat{\rho}$	0,021373	Durbin's h	1,909239	

LM test for autocorrelation up to order 1 –

Null hypothesis: no autocorrelation

Test statistic: LMF = 2,01786

with p-value = $P(F(1, 282) > 2,01786) = 0,156563$

LM test for autocorrelation up to order 2 –

Null hypothesis: no autocorrelation

Test statistic: LMF = 2,02437

with p-value = $P(F(2, 281) > 2,02437) = 0,133999$

LM test for autocorrelation up to order 3 –

Null hypothesis: no autocorrelation

Test statistic: LMF = 1,37573

with p-value = $P(F(3, 280) > 1,37573) = 0,250412$

LM test for autocorrelation up to order 4 –

Null hypothesis: no autocorrelation

Test statistic: LMF = 1,08183

with p-value = $P(F(4, 279) > 1,08183) = 0,365743$

White's test for heteroskedasticity –

Null hypothesis: heteroskedasticity not present

Test statistic: LM = 186,716

with p-value = $P(\chi^2(44) > 186,716) = 1,69401\text{e-}019$

White's test for heteroskedasticity (squares only) –

Null hypothesis: heteroskedasticity not present

Test statistic: LM = 75,0501

with p-value = $P(\chi^2(16) > 75,0501) = 1,28097\text{e-}009$

Test for normality of residual –

Null hypothesis: error is normally distributed

Test statistic: $\chi^2(2) = 59,4075$

with p-value = 1,25841e-013

OLS, using observations 1988:09–2012:12 ($T = 292$)

Dependent variable: l_Xc_R

	Coefficient	Std. Error	<i>t</i> -ratio	p-value
const	0,0872586	0,0463734	1,8817	0,0609
l_Xc_R_1	1,31253	0,0579003	22,6689	0,0000
l_Xc_R_2	−0,478637	0,0957294	−4,9999	0,0000
l_Xc_R_3	0,153323	0,0995662	1,5399	0,1247
l_Xc_R_4	−0,0929228	0,0994900	−0,9340	0,3511
l_Xc_R_5	0,149534	0,0991742	1,5078	0,1327
l_Xc_R_6	−0,122374	0,0980757	−1,2478	0,2132
l_Xc_R_7	0,281488	0,0938175	3,0004	0,0029
l_Xc_R_8	−0,222584	0,0571830	−3,8925	0,0001
Mean dependent var	4,494924	S.D. dependent var		0,128696
Sum squared resid	0,134947	S.E. of regression		0,021837
R^2	0,972001	Adjusted R^2		0,971210
$F(8, 283)$	1228,079	P-value(F)		8,4e−215
Log-likelihood	706,8958	Akaike criterion		−1395,792
Schwarz criterion	−1362,701	Hannan–Quinn		−1382,537
$\hat{\rho}$	0,019442	Durbin's h		2,121418

LM test for autocorrelation up to order 1 –

Null hypothesis: no autocorrelation

Test statistic: LMF = 2,00912

with p-value = $P(F(1, 282) > 2,00912) = 0,15746$

LM test for autocorrelation up to order 2 –

Null hypothesis: no autocorrelation

Test statistic: LMF = 1,99863

with p-value = $P(F(2, 281) > 1,99863) = 0,137443$

LM test for autocorrelation up to order 3 –

Null hypothesis: no autocorrelation

Test statistic: LMF = 1,62489

with p-value = $P(F(3, 280) > 1,62489) = 0,183791$

LM test for autocorrelation up to order 4 –

Null hypothesis: no autocorrelation

Test statistic: LMF = 1,32055

with p-value = $P(F(4, 279) > 1,32055) = 0,262451$

White's test for heteroskedasticity –

Null hypothesis: heteroskedasticity not present

Test statistic: LM = 216,543

with p-value = $P(\chi^2(44) > 216,543) = 1,22252\text{e-}024$

White's test for heteroskedasticity (squares only) –

Null hypothesis: heteroskedasticity not present

Test statistic: LM = 106,282

with p-value = $P(\chi^2(16) > 106,282) = 2,27342\text{e-}015$

Test for normality of residual –

Null hypothesis: error is normally distributed

Test statistic: $\chi^2(2) = 125,234$

with p-value = 6,39354e-028

OLS, using observations 1988:09–2012:12 ($T = 292$)

Dependent variable: Xc_R

	Coefficient	Std. Error	t-ratio	p-value
const	4,39434	1,54109	2,8514	0,0047
time	−0,00382659	0,00182335	−2,0987	0,0367
Xc_R_1	1,30978	0,0574543	22,7968	0,0000
Xc_R_2	−0,483225	0,0946989	−5,1028	0,0000
Xc_R_3	0,190629	0,0985453	1,9344	0,0541
Xc_R_4	−0,118996	0,0987323	−1,2052	0,2291
Xc_R_5	0,0907490	0,0976177	0,9296	0,3534
Xc_R_6	−0,114202	0,0951184	−1,2006	0,2309
Xc_R_7	0,330258	0,0901682	3,6627	0,0003
Xc_R_8	−0,247983	0,0553393	−4,4811	0,0000
Mean dependent var	90,27052	S.D. dependent var	10,88166	
Sum squared resid	932,2474	S.E. of regression	1,818197	
R^2	0,972945	Adjusted R^2	0,972081	
$F(9, 282)$	1126,799	P-value(F)	2,4e−215	
Log-likelihood	−583,8133	Akaike criterion	1187,627	
Schwarz criterion	1224,394	Hannan–Quinn	1202,354	
$\hat{\rho}$	0,018813	Durbin's h	1,616572	

LM test for autocorrelation up to order 1 –

Null hypothesis: no autocorrelation

Test statistic: LMF = 1,42423

with p-value = $P(F(1, 281) > 1,42423) = 0,233716$

LM test for autocorrelation up to order 2 –

Null hypothesis: no autocorrelation

Test statistic: LMF = 2,01047

with p-value = $P(F(2, 280) > 2,01047) = 0,135855$

LM test for autocorrelation up to order 3 –

Null hypothesis: no autocorrelation

Test statistic: LMF = 1,44505

with p-value = $P(F(3, 279) > 1,44505) = 0,229924$

LM test for autocorrelation up to order 4 –

Null hypothesis: no autocorrelation

Test statistic: LMF = 1,08877

with p-value = $P(F(4, 278) > 1,08877) = 0,362337$

White's test for heteroskedasticity –

Null hypothesis: heteroskedasticity not present

Test statistic: LM = 209,833

with p-value = $P(\chi^2(54) > 209,833) = 3,11608\text{e-}020$

White's test for heteroskedasticity (squares only) –

Null hypothesis: heteroskedasticity not present

Test statistic: LM = 116,142

with p-value = $P(\chi^2(18) > 116,142) = 2,23481\text{e-}016$

Test for normality of residual –

Null hypothesis: error is normally distributed

Test statistic: $\chi^2(2) = 67,6665$

with p-value = 2,02491e-015

III Appendix

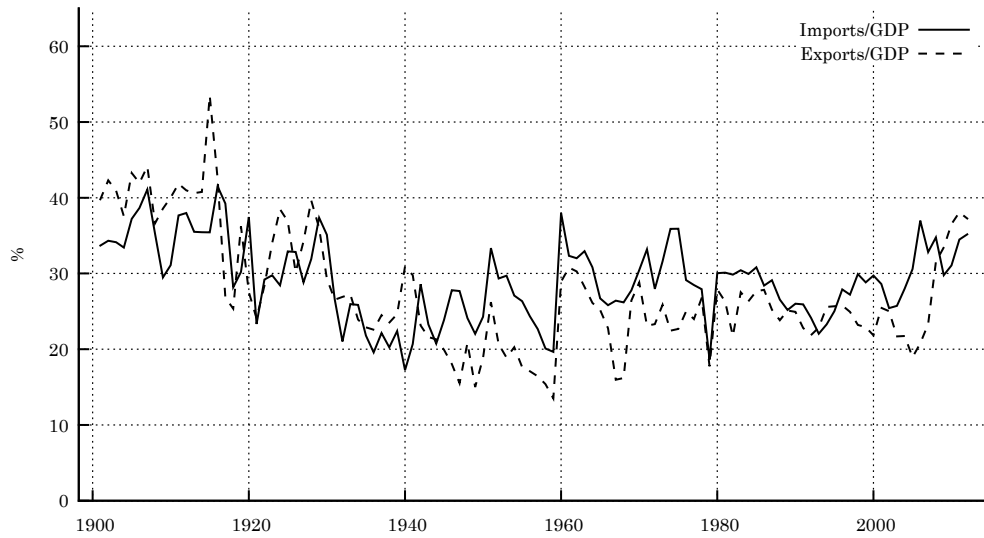


Figure III.1: Total annual share of exports and imports of GDP, each year for the period 1901-2012, at current prices. Data source: *cf.* Appendix I.

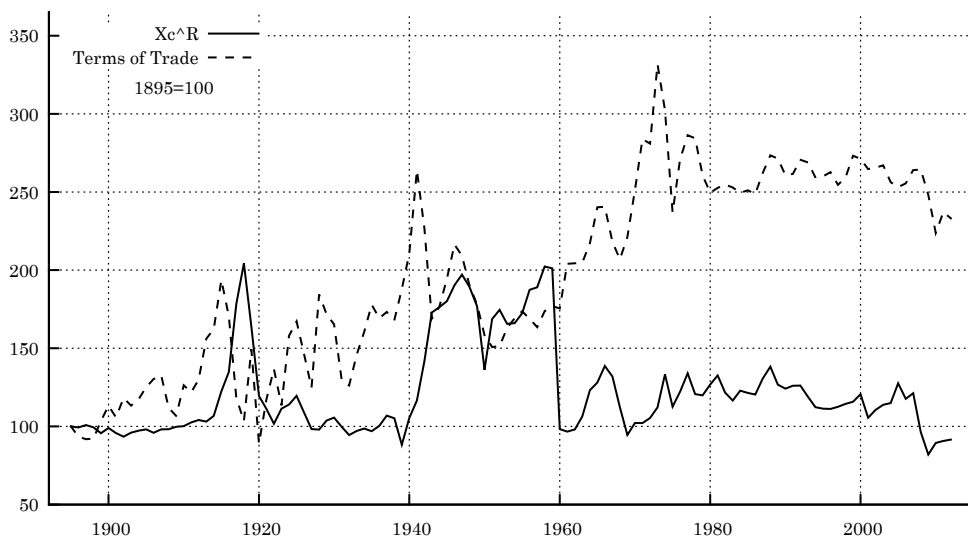


Figure III.2: Development of the new Xc^R & terms of trade for Iceland, annual frequency: 1895 to 2012 (1895=2012). Data source: *cf.* Appendix I.



Figure III.3: Share of the exports & imports that are included in this study, of Iceland's total exports & imports, each year. 1895 to 1987. Data source: *cf.* Appendix I.

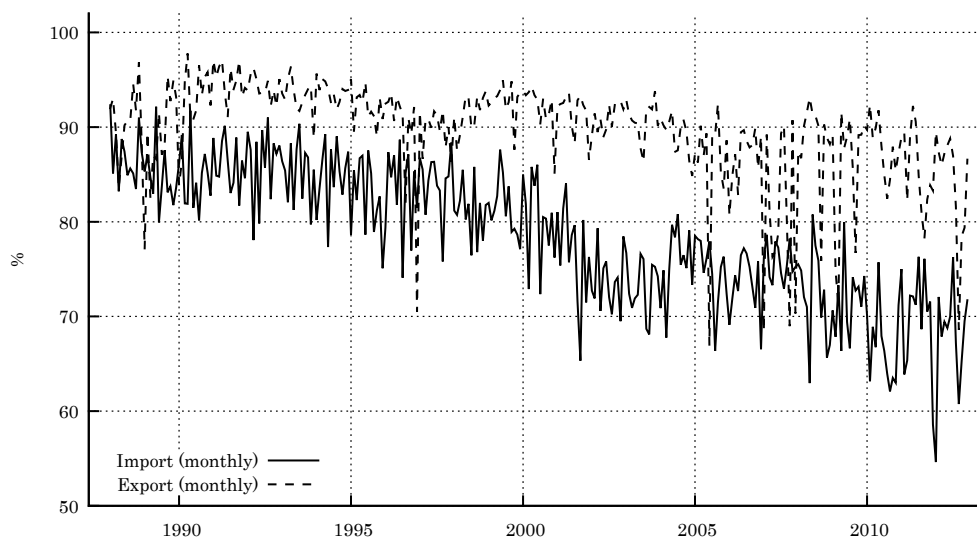


Figure III.4: Share of the exports & imports that are included in this study, of Iceland's total exports & imports, each month. 1988 to 2012. Data source: *cf.* Appendix I.

The drop in annual imports and exports during the 1950s is due to external trade between Iceland and the USSR during the period. USSR is not included in this research.



Figure III.5: Comparison of the new real effective exchange rate of the Icelandic króna (Xc^R) & the official real exchange rate of The Central Bank, monthly frequency: 1988 to 2012 (Jan 1988 = 100). Data source: *cf.* Appendix I & calculations in Section 3.

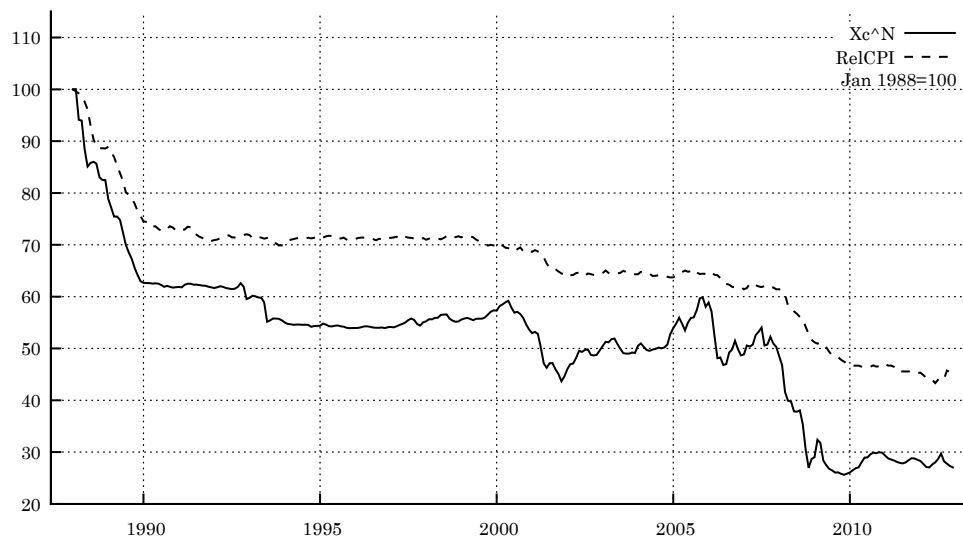


Figure III.6: The new nominal effective króna exchange rate (Xc^N) and Relative prices ($RelCPI$), monthly frequency: 1988 to 2012 (Jan 1988 = 100). Data source: *cf.* Appendix I & calculations in Section 3.

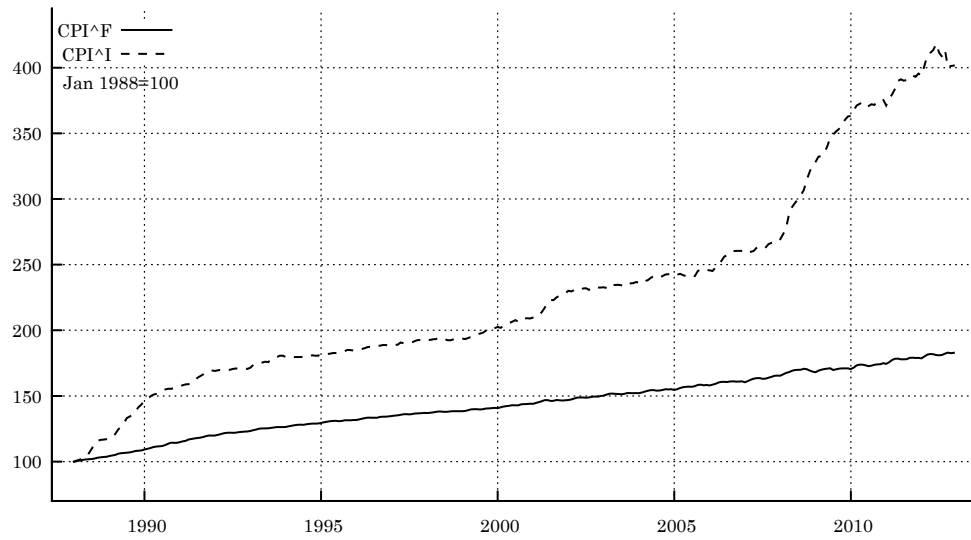


Figure III.7: Comparison of the Icelandic (CPI^I) & foreign consumer price indices (CPI^F), monthly frequency: 1988 to 2012 (Jan 1988 = 100). Data source: *cf.* Appendix I & calculations in Section 3.

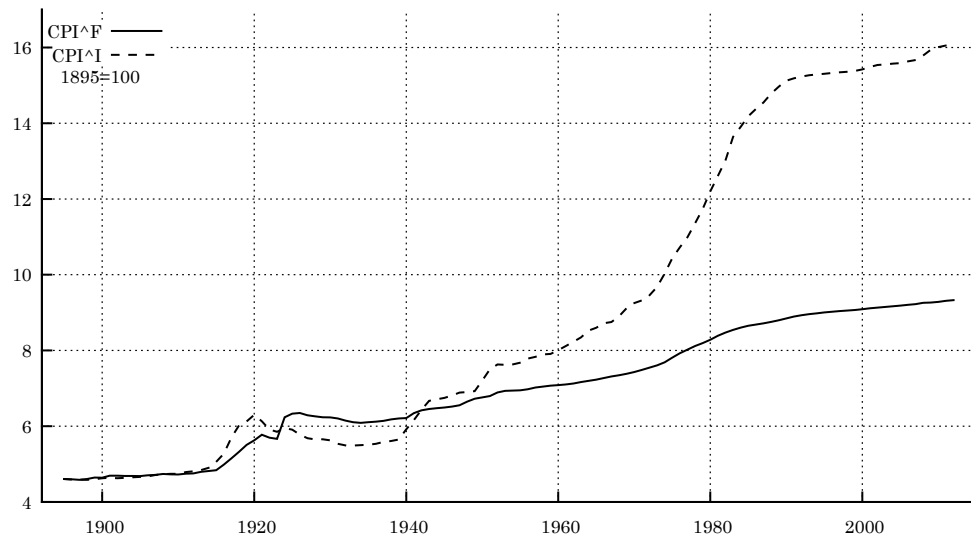


Figure III.8: Comparison of the Icelandic & foreign consumer price indices in logarithmic scale, annual frequency: 1895 to 2012 (1895 = 100). Data source: *cf.* Appendix I & calculations in Section 3.

Table III.1: Historical indices 1895 to 1987, annual observations.

Date	Xc^R	CPI^I	CPI^F	Xc^N		Xc^R	CPI^I	CPI^F	Xc^N
	1895=100					1895=100			
'95	100,00	100,00	100,00	100,00	'36	100,32	253,82	454,55	179,67
'96	99,35	98,50	99,45	100,31	'37	106,91	266,76	464,70	186,24
'97	100,86	98,30	98,01	100,56	'38	105,21	273,16	483,85	186,35
'98	99,41	98,11	100,13	101,46	'39	88,25	283,54	494,97	154,06
'99	95,64	99,48	104,17	100,15	'40	105,42	371,73	500,77	142,02
'00	98,95	102,07	103,60	100,43	'41	116,58	475,44	569,27	139,59
'01	95,77	103,39	109,11	101,06	'42	141,65	623,30	613,43	139,41
'02	93,40	102,05	109,27	100,01	'43	172,89	787,85	635,27	139,41
'03	95,99	103,38	108,33	100,59	'44	176,30	822,52	650,38	139,41
'04	97,32	104,72	108,42	100,76	'45	180,11	852,13	660,18	139,54
'05	98,11	105,98	108,27	100,23	'46	190,40	907,51	677,77	142,20
'06	95,89	107,25	110,56	98,86	'47	197,09	981,02	702,81	141,20
'07	98,11	111,11	111,73	98,65	'48	189,27	993,78	770,86	146,81
'08	98,22	113,66	114,36	98,82	'49	176,88	1018,62	834,59	144,92
'09	99,76	114,91	113,31	98,37	'50	136,23	1348,65	862,56	87,13
'10	100,22	114,91	112,79	98,37	'51	168,69	1813,94	894,75	83,21
'11	102,53	120,09	115,32	98,46	'52	174,60	2064,26	983,82	83,21
'12	104,13	122,73	115,89	98,32	'53	165,63	2041,56	1025,04	83,16
'13	103,06	126,66	120,87	98,35	'54	166,08	2064,01	1032,20	83,05
'14	106,77	134,38	123,57	98,18	'55	172,40	2158,96	1042,37	83,24
'15	122,50	157,63	126,14	98,03	'56	187,37	2409,40	1070,51	83,25
'16	134,84	195,14	146,63	101,32	'57	189,05	2517,82	1120,49	84,13
'17	178,26	299,74	172,94	102,85	'58	202,33	2684,00	1147,00	86,47
'18	204,39	412,15	204,91	101,62	'59	201,15	2724,26	1178,91	87,05
'19	163,85	458,72	246,37	88,00	'60	98,26	3004,85	1194,63	39,07
'20	119,47	544,04	277,90	61,02	'61	96,71	3356,42	1216,95	35,07
'21	111,16	460,26	322,28	77,84	'62	98,08	3755,84	1245,62	32,53
'22	101,75	369,59	297,67	81,95	'63	106,38	4221,56	1292,96	32,58
'23	111,38	347,78	288,36	92,35	'64	123,16	5048,99	1336,07	32,59
'24	113,97	383,95	510,91	151,66	'65	128,12	5422,61	1380,14	32,61
'25	119,55	368,59	561,21	182,02	'66	138,67	6116,70	1438,03	32,60
'26	108,89	323,26	571,14	192,39	'67	131,94	6318,56	1501,24	31,35
'27	98,29	293,52	538,53	180,34	'68	112,23	7342,16	1551,01	23,71
'28	97,98	284,42	524,55	180,70	'69	94,55	9111,62	1613,30	16,74
'29	103,77	285,84	510,83	185,46	'70	102,22	10414,58	1687,37	16,56
'30	105,64	278,12	509,51	193,54	'71	102,16	11174,85	1785,83	16,33
'31	99,78	253,65	494,86	194,67	'72	105,39	12784,03	1896,64	15,64
'32	94,43	243,25	467,96	181,67	'73	112,17	15941,68	2010,57	14,15
'33	97,11	242,03	448,84	180,09	'74	133,33	22669,07	2180,45	12,82
'34	98,66	244,69	440,26	177,52	'75	112,61	34048,95	2469,40	8,17
'35	96,97	247,38	448,77	175,91	'76	122,24	45489,39	2771,62	7,45

Table III.1 contd.

Date	Xc^R	CPI^I	CPI^F	Xc^N		Xc^R	CPI^I	CPI^F	Xc^N
	<i>1895=100</i>					<i>1895=100</i>			
'77	133,96	59363,6	3045,5	6,87	'83	116,58	838580,9	5128,0	0,71
'78	120,68	85661,7	3353,8	4,72	'84	122,92	1092670,9	5449,9	0,61
'79	119,93	124809,2	3624,9	3,48	'85	121,39	1449974,3	5727,4	0,48
'80	126,84	198446,6	3961,5	2,53	'86	120,38	1748669,1	5902,1	0,41
'81	132,63	298860,6	4400,2	1,95	'87	130,68	2079167,5	6100,4	0,38
'82	121,58	451578,3	4791,5	1,29					

Source: *cf.* calculations in section 3

Table III.2: Historical indices 1988 to 2012, monthly observations.

Date	Xc^R	CPI^I	CPI^F	Xc^N		Xc^R	CPI^I	CPI^F	Xc^N
	<i>2005=100</i>					<i>2005=100</i>			
01'88	117,90	41,27	63,68	181,90	06'91	101,11	66,80	74,89	113,35
02'88	118,44	41,59	63,91	181,99	07'91	102,13	67,65	75,09	113,35
03'88	111,84	41,91	64,16	171,21	08'91	102,55	68,19	75,27	113,21
04'88	112,21	42,34	64,50	170,95	09'91	102,70	68,72	75,61	113,00
05'88	106,82	42,98	64,70	160,83	10'91	102,56	69,04	76,06	112,99
06'88	104,41	43,72	64,84	154,84	11'91	102,66	69,57	76,34	112,65
07'88	108,70	45,21	64,91	156,08	12'91	102,98	69,89	76,29	112,41
08'88	112,13	46,70	65,16	156,47	01'92	102,55	69,78	76,34	112,20
09'88	113,62	47,76	65,52	155,86	02'92	102,59	69,99	76,68	112,39
10'88	110,48	48,08	65,74	151,06	03'92	102,61	70,10	77,05	112,77
11'88	109,76	48,19	65,90	150,10	04'92	102,10	70,21	77,44	112,62
12'88	109,79	48,29	66,01	150,06	05'92	101,45	70,21	77,63	112,18
01'89	104,61	48,40	66,37	143,45	06'92	101,02	70,10	77,70	111,97
02'89	103,57	49,15	66,62	140,41	07'92	101,42	70,42	77,62	111,80
03'89	102,31	49,89	66,92	137,23	08'92	101,57	70,53	77,71	111,91
04'89	104,32	51,27	67,46	137,26	09'92	101,78	70,53	77,97	112,53
05'89	105,20	52,34	67,72	136,11	10'92	102,83	70,53	78,09	113,86
06'89	103,69	53,40	67,84	131,73	11'92	101,55	70,53	78,22	112,63
07'89	103,01	55,00	67,97	127,31	12'92	97,43	70,42	78,27	108,29
08'89	101,39	55,42	68,13	124,65	01'93	98,03	70,85	78,56	108,71
09'89	100,45	56,17	68,47	122,45	02'93	99,43	71,70	78,91	109,44
10'89	99,17	57,23	68,81	119,24	03'93	99,40	72,12	79,28	109,27
11'89	98,85	58,40	68,94	116,70	04'93	98,71	72,23	79,65	108,84
12'89	98,24	59,25	69,09	114,55	05'93	98,73	72,44	79,79	108,74
01'90	99,17	60,53	69,57	113,98	06'93	97,57	72,65	79,80	107,16
02'90	99,23	60,85	69,86	113,93	07'93	91,19	72,55	79,82	100,33
03'90	100,24	61,80	70,24	113,93	08'93	92,32	73,29	80,02	100,80
04'90	100,28	62,34	70,68	113,71	09'93	93,46	73,93	80,25	101,45
05'90	100,26	62,55	71,00	113,80	10'93	93,58	74,14	80,40	101,48
06'90	100,84	63,08	71,13	113,70	11'93	94,00	74,57	80,39	101,34
07'90	101,01	63,51	71,21	113,27	12'93	93,54	74,57	80,41	100,86
08'90	100,37	63,93	71,71	112,59	01'94	92,15	74,14	80,50	100,05
09'90	100,15	64,14	72,33	112,92	02'94	91,11	73,93	80,81	99,59
10'90	99,19	64,14	72,82	112,61	03'94	90,78	74,04	81,08	99,42
11'90	99,25	64,36	72,81	112,29	04'94	90,48	74,14	81,35	99,27
12'90	100,13	64,78	72,76	112,46	05'94	90,37	74,14	81,51	99,35
01'91	99,87	64,89	73,12	112,54	06'94	90,32	74,14	81,57	99,37
02'91	99,88	65,31	73,52	112,43	07'94	90,42	74,25	81,51	99,26
03'91	100,66	65,53	73,74	113,28	08'94	90,40	74,46	81,80	99,31
04'91	100,29	65,63	74,39	113,67	09'94	90,12	74,46	81,98	99,22
05'91	100,37	65,95	74,68	113,65	10'94	89,66	74,67	82,07	98,54

Table III.2 contd.

Date	Xc^R	CPI^I	CPI^F	Xc^N		Xc^R	CPI^I	CPI^F	Xc^N
<i>2005=100</i>						<i>2005=100</i>			
11'94	89,79	74,57	82,10	98,86	07'98	93,48	79,82	87,82	102,85
12'94	89,77	74,57	82,15	98,90	08'98	93,03	79,42	87,84	102,89
01'95	90,12	75,10	82,45	98,93	09'98	91,45	79,42	88,06	101,40
02'95	90,49	75,10	82,73	99,68	10'98	91,14	79,72	88,11	100,74
03'95	89,88	75,10	83,00	99,33	11'98	90,99	79,92	88,14	100,34
04'95	89,24	75,20	83,26	98,80	12'98	90,85	79,72	88,13	100,44
05'95	89,22	75,40	83,39	98,68	01'99	91,71	79,92	88,09	101,08
06'95	89,41	75,40	83,44	98,94	02'99	91,75	79,82	88,25	101,45
07'95	89,92	75,60	83,25	99,01	03'99	91,94	80,12	88,61	101,68
08'95	89,85	75,90	83,40	98,73	04'99	91,64	80,52	89,01	101,30
09'95	89,53	76,00	83,72	98,61	05'99	91,53	80,82	89,11	100,91
10'95	89,63	76,41	83,72	98,21	06'99	92,53	81,33	89,09	101,37
11'95	89,39	76,31	83,73	98,09	07'99	92,97	81,53	88,93	101,41
12'95	89,21	76,20	83,82	98,13	08'99	93,12	81,83	89,11	101,40
01'96	89,40	76,41	83,86	98,13	09'99	93,89	82,43	89,41	101,83
02'96	89,26	76,51	84,17	98,20	10'99	95,38	83,03	89,49	102,80
03'96	89,32	76,71	84,51	98,41	11'99	96,14	82,93	89,59	103,86
04'96	89,62	77,01	84,82	98,72	12'99	96,77	83,23	89,75	104,34
05'96	89,84	77,31	84,99	98,76	01'00	97,26	83,63	89,63	104,23
06'96	89,70	77,31	84,96	98,57	02'00	97,98	83,33	89,98	105,79
07'96	89,62	77,41	84,92	98,31	03'00	98,71	83,84	90,39	106,43
08'96	89,83	77,71	84,98	98,23	04'00	100,03	84,54	90,57	107,17
09'96	89,47	77,71	85,31	98,22	05'00	100,67	84,84	90,76	107,69
10'96	89,62	77,91	85,47	98,32	06'00	98,63	85,24	91,06	105,36
11'96	89,42	77,91	85,45	98,06	07'00	97,59	85,74	90,94	103,50
12'96	89,35	77,71	85,57	98,39	08'00	97,31	85,24	90,93	103,81
01'97	89,50	77,91	85,76	98,51	09'00	96,09	85,34	91,51	103,04
02'97	89,28	78,01	85,95	98,36	10'00	95,81	86,24	91,54	101,68
03'97	89,47	78,01	86,10	98,75	11'00	93,68	86,35	91,62	99,40
04'97	90,40	78,71	86,38	99,21	12'00	91,76	86,24	91,75	97,62
05'97	90,24	78,51	86,62	99,56	01'01	90,96	86,55	91,65	96,33
06'97	90,66	78,51	86,68	100,09	02'01	90,92	86,55	92,11	96,77
07'97	91,65	78,61	86,58	100,93	03'01	90,62	87,25	92,49	96,07
08'97	92,18	78,82	86,76	101,48	04'01	86,64	88,25	93,00	91,29
09'97	91,87	79,22	87,03	100,93	05'01	82,18	89,66	93,50	85,70
10'97	90,89	79,52	87,09	99,54	06'01	82,18	91,27	93,51	84,20
11'97	90,23	79,42	87,11	98,97	07'01	84,80	92,07	93,13	85,78
12'97	91,03	79,32	87,25	100,14	08'01	84,84	92,07	93,16	85,84
01'98	91,76	79,62	87,18	100,48	09'01	83,00	92,87	93,54	83,60
02'98	92,15	79,52	87,34	101,21	10'01	81,95	93,37	93,44	82,00
03'98	92,15	79,72	87,52	101,17	11'01	79,87	93,78	93,28	79,45
04'98	92,48	79,82	87,76	101,68	12'01	81,83	94,18	93,43	81,19
05'98	92,61	80,12	88,01	101,73	01'02	84,97	94,98	93,55	83,69
06'98	93,70	80,22	87,94	102,71	02'02	86,36	94,78	93,79	85,45

Table III.2 contd.

Date	Xc^R	CPI^I	CPI^F	Xc^N		Xc^R	CPI^I	CPI^F	Xc^N
<i>2005=100</i>						<i>2005=100</i>			
03'02	86,54	95,18	94,25	85,69	11'05	109,58	101,31	100,69	108,92
04'02	88,07	95,08	94,69	87,71	12'05	106,29	101,51	100,85	105,60
05'02	90,39	95,08	94,81	90,13	01'06	107,95	101,41	100,59	107,08
06'02	90,60	95,68	94,77	89,73	02'06	104,15	101,20	101,00	103,94
07'02	91,51	95,78	94,65	90,43	03'06	96,28	102,31	101,38	95,40
08'02	91,11	95,28	94,77	90,62	04'06	88,48	103,11	102,04	87,56
09'02	89,39	95,78	95,08	88,73	05'06	89,50	104,32	102,33	87,80
10'02	89,38	96,18	95,25	88,51	06'06	87,93	105,72	102,37	85,14
11'02	89,50	95,98	95,15	88,73	07'06	88,68	106,12	102,28	85,47
12'02	90,70	95,98	95,48	90,23	08'06	93,10	106,63	102,52	89,52
01'03	92,17	96,08	95,68	91,78	09'06	94,87	107,43	102,60	90,60
02'03	92,94	95,88	96,21	93,25	10'06	98,26	107,53	102,46	93,62
03'03	93,47	96,99	96,62	93,11	11'06	95,24	107,53	102,45	90,74
04'03	94,48	96,89	96,64	94,24	12'06	92,76	107,53	102,61	88,52
05'03	94,68	96,79	96,52	94,42	01'07	93,77	107,83	102,19	88,86
06'03	92,96	96,89	96,46	92,55	02'07	96,69	107,93	102,71	92,01
07'03	91,20	96,69	96,31	90,85	03'07	95,02	107,23	103,38	91,61
08'03	89,11	96,29	96,53	89,33	04'07	95,58	107,53	103,89	92,35
09'03	89,23	96,99	96,90	89,15	05'07	99,69	108,53	104,16	95,67
10'03	89,48	97,29	96,90	89,13	06'07	101,25	108,94	104,15	96,81
11'03	90,03	97,39	96,83	89,51	07'07	102,99	108,84	103,85	98,27
12'03	90,07	97,69	96,93	89,37	08'07	96,08	108,53	103,93	92,00
01'04	92,57	97,59	96,84	91,86	09'07	96,97	109,64	104,37	92,32
02'04	92,74	97,19	97,14	92,69	10'07	99,82	110,04	104,74	95,02
03'04	91,88	97,99	97,63	91,54	11'07	97,28	110,44	105,25	92,70
04'04	90,71	98,29	97,98	90,42	12'07	96,60	111,24	105,42	91,54
05'04	90,74	99,00	98,34	90,14	01'08	93,11	111,14	105,34	88,25
06'04	91,78	99,60	98,32	90,60	02'08	90,56	112,75	105,94	85,09
07'04	91,93	99,30	98,09	90,80	03'08	81,21	114,56	106,71	75,65
08'04	92,23	99,20	98,16	91,27	04'08	80,72	118,98	107,05	72,63
09'04	92,09	99,60	98,42	91,01	05'08	81,44	121,29	107,71	72,33
10'04	92,53	100,10	98,80	91,32	06'08	78,09	122,59	108,11	68,86
11'04	93,76	100,20	98,69	92,35	07'08	78,61	123,69	108,19	68,75
12'04	97,71	100,50	98,79	96,04	08'08	79,99	125,10	108,27	69,23
01'05	99,80	100,10	98,40	98,11	09'08	74,98	126,61	108,71	64,38
02'05	100,91	100,00	98,81	99,71	10'08	66,24	129,82	108,47	55,34
03'05	102,70	100,30	99,38	101,76	11'08	60,24	132,33	107,82	49,09
04'05	99,78	99,90	99,78	99,66	12'08	65,45	134,64	107,34	52,18
05'05	96,94	99,60	99,95	97,28	01'09	66,83	135,44	106,98	52,79
06'05	100,00	100,00	100,00	100,00	02'09	74,92	137,15	107,80	58,89
07'05	101,49	99,80	99,96	101,65	03'09	73,30	137,35	108,24	57,76
08'05	101,21	99,60	100,27	101,89	04'09	65,73	138,35	108,58	51,59
09'05	104,85	101,20	100,89	104,53	05'09	64,54	140,36	108,76	50,01
10'05	109,28	101,71	101,01	108,53	06'09	63,93	143,07	108,96	48,69

Table III.2 contd.

Date	Xc^R	CPI^I	CPI^F	Xc^N		Xc^R	CPI^I	CPI^F	Xc^N
<i>2005=100</i>						<i>2005=100</i>			
07'09	64,20	144,08	108,13	48,18	04'11	72,06	158,43	113,54	51,64
08'09	63,38	145,08	108,42	47,36	05'11	72,43	160,94	113,63	51,14
09'09	63,72	145,88	108,73	47,49	06'11	72,37	161,45	113,30	50,78
10'09	63,66	147,59	108,86	46,95	07'11	71,97	161,04	113,28	50,62
11'09	63,70	148,69	108,87	46,64	08'11	72,54	161,24	113,36	51,00
12'09	64,65	149,80	108,89	46,99	09'11	73,64	162,05	113,99	51,80
01'10	65,49	149,90	108,58	47,44	10'11	74,77	162,65	114,03	52,42
02'10	66,96	151,81	109,28	48,20	11'11	74,56	162,25	113,91	52,35
03'10	67,92	153,21	110,35	48,92	12'11	74,29	163,25	114,00	51,88
04'10	68,42	153,71	110,69	49,27	01'12	73,61	162,65	113,71	51,46
05'10	71,19	154,32	110,66	51,05	02'12	72,84	165,66	114,66	50,42
06'10	73,41	154,02	110,39	52,62	03'12	72,11	168,88	115,57	49,35
07'10	73,35	153,01	109,97	52,71	04'12	72,11	169,78	115,89	49,22
08'10	75,02	153,61	110,18	53,81	05'12	74,10	170,68	115,76	50,26
09'10	75,46	153,41	110,60	54,40	06'12	76,28	172,59	115,34	50,98
10'10	75,49	154,42	110,83	54,18	07'12	76,92	169,78	115,24	52,21
11'10	75,93	154,42	110,91	54,54	08'12	78,94	168,57	115,44	54,06
12'10	75,65	155,02	111,39	54,36	09'12	75,48	170,58	116,08	51,36
01'11	73,54	153,21	111,06	53,31	10'12	71,62	165,16	116,52	50,53
02'11	72,76	155,32	111,89	52,41	11'12	70,86	165,66	116,26	49,73
03'11	72,09	156,73	112,93	51,95	12'12	70,06	165,76	116,46	49,23

Source: *cf.* calculations in section 3

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