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Price Stability and Inflation Persistence during the International Gold standard: The Scandinavian case

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Abstract

In the 1870s the three Scandinavian countries Denmark, Norway and Sweden formed the Scandinavian Currency Union. Both the adoption of gold and the monetary union were supposed to lead to price stability in and between these countries. By drawing on new indices of consumer prices the present paper offers an examination of inflation dynamics, defined as price stability and inflation persistence, in the periphery of Scandinavia during the heyday of the international gold standard.

1 Background

According to Willis there are two main statistical measures that have been employed in recent research when investigating inflation dynamics. These are "volatility, or how much inflation varies form quarter to quarter or year to year; and persistence, or the speed to with which inflation returns to baseline after a shock."[1] Furthermore, "Other things equal, less persistence leads to less variability. Lower persistence is associated with faster but smaller swings in inflation over time that, in statistical terms, reduce the overall variability of inflation."

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[1]Willis 2003, 7.

Thus, when the international gold standard was introduced worldwide in the 1870s and 1880s, the feature of inflation dynamics should be mirrored in price stability and inflation persistence.[2] The price stability should naturally be found in two arenas, the domestic and the international. In the first place, fixed gold values of currencies would lead to stable domestic values of the currencies. Thus, domestic prices or inflation would tend to stay stable over time. Secondly, by the international adoption of gold, countries would have a fixed value of their currency in gold, and thus cross-border prices should stay stable.

The three Scandinavian countries, Denmark, Norway and Sweden can be seen as peripheral countries in the nineteenth and twentieth century. Not because they were located far from the political and economical centers of the world at the time. They were certainly not, as the distance first to the UK in the nineteenth century and thereafter to the US in the twentieth century was not at all substantial. Thus, they may have profited from being geographically closely located to the centers of to world. However, in economic terms they were small and peripheral countries compared to the great powers both on the European continent, the British isles and in the new world, perhaps with a possible exception for parts of Swedish industry. Despite their peripheral role in the world economy, the three of them were early adopters of gold, as they all took part in the international gold standard system from January 1874. They also founded a common currency union, The Scandinavian Currency Union, effective for all three countries from January 1877. The union was effective to the start of World War I, which led to its breakdown, despite it formally existed for several years after it ceased functioning.[3] The move from a silver standard to a gold standard was being planned for several years. Representatives from the three countries discussed the setting up of a the common currency union.[4] (The union has also been called the Scandinavian Montary Union).[5] This plan initially failed due to Norwegian reluctance to taking part in another Swedish-Norwegian union, as the two countries were already in a personal union, with the Swedish king being head of state of both Norway and Sweden.[6] By their early adoption to gold and the setting up of a common currency union the three countries can be seen as international pioneers, despite their peripheral importance to

[2]Bordo and Schwartz 1984, Eichengreen and Bayoumi 1995, Foreman-Peck 1995, 154-160.

[3]Bergman, Gerlach and Jonung 1993, 507-517.

[4]Talia 2004a.

[5] See e.g. Øksendal 2007, 125-148.

[6] On the Norwegian process into the Scandinavian Currency Union, see Øksendal 2006, 187-213.

the international economy.

However, the economic and political pros rapidly became stronger than the cons. Thus, from January 1st 1877, the common currency union for all three Scandinavian countries came to being. During the effective regime of the Scandinavian Currency Union till August 1914 the three countries had the same value of account, i.e. the Danish, the Swedish and the Norwegian krone. Their values in pure gold were set equally to 0.40323 gram per krone. They were all legal tender in all the three countries. Thus, the Danish, the Norwegian and the Swedish krone had the same par value in gold, and could be used freely all over Scandinavia.[7]

Task of paper On this common background it is of interest to find out if price stability did exist during the times of the efficient international gold standard in the Scandinavian countries from its introduction in January 1874 until the start of World War I in July/August 1914. This task leaves us with two questions that we want to examine in this paper:

1. Did domestic price stability exist for the Scandinavian countries, Denmark, Norway and Sweden during the gold standard period January 1874–July 1914?

2. Did cross-border price stability exist for the Scandinavian countries, Denmark, Norway and Sweden during the gold standard period January 1874–July 1914?

By utilizing existing and new price data, compiled from primary sources and thereafter used in the construction of price indices for all the three countries, we are in a position to examine whether price stability existed.[8] These data have been made available following recent historical monetary projects by the central banks of Norway and Sweden, and earlier quantitative research into Danish economic history.[9]

[7] Talia 2004b.

[8] Key sources for Denmark have been public records, price currents and private price lists. These have been compiled by several historians and were brought together by Sven Aage Hansen in the 1970s, see Hansen 1983, 301-370. A similar background exists for the Swedish price index constructed by Rodney Edvinsson and Johan Söderberg, see Edvinsson and Söderberg 2007, 1-42. A key source for Norwegian price data has been the Professor Dr Ingvar B Wedervang's Historical Archive on Wages and Prices, kept at the Norwegian School of Economics and Business Administration. For information on the archive, see Grytten 2007, 203-230.

[9] Eitrheim, Klovland and Qvigstad 2004, Eitrheim, Klovland and Qvigstad 2007, www.norges-bank.no/Templates/Article____42332.aspx and `http://www.riksbank.com/templates/Page.aspx?id=27394`, Hansen 1983, 229-374.

2 Data

In order to investigate price stability during the efficient international gold standard period we have to have a broader look at price history to see if price stability was stronger during the period in question. Thus, we expand the time series to cover the period from 1815 to 2000, thereby including the post-Napoleonic period, the silver standard period, the troubled war and interwar years 1914-1945 and the postwar years 1945-2000. We basically look into price data from the three countries under investigation. The data differ in character between the countries. However, they still serve as valid, reliable and comparable sources. We offer an overview of the data sets we use below.

2.1 Denmark

Historical prices have been investigated for decades in Denmark by the Price History Group at Copenhagen University. As result two volumes of historical prices and wages have been published.[10] As part of the project we now expect a publication presenting a continuous CPI from medieval times to present days. As part of a forthcoming continuous consumer price index for Denmark Svend Aage Hansen has constructed a combined cost of living index and consumer price index for Denmark 1815-1870.[11] Unfortunately, Hansen did not focus on documentation of his index, but leaves us with some traces. His index is based on commodity prices he collected for 79 products, of these less than 50 were consumer commodities, categorized in seven consumption groups. The prices were compiled from different sources, mostly Danish, but also some foreign sources. The Danish price data were taken mainly from Copenhagen.[12] Hansen's price index must be considered a semi-cost of living/consumer price index. The price material consist of six types of prices: wholesale prices, export prices, import prices, institutional prices, foreign prices and domestic market prices to consumers, of which the first and last groups are dominant.

Using the traditional Laspeyres approach, Hansen established fixed weights. He picked 1840 as his base year. His well-documented weights are based on estimated consumer expenditure offered in the historical national accounts for Denmark. Hansen did not have price data for three important groups: transport, other consumer commodities and other services.[13]

[10] Friis and Glamann 1958, Andersen and Pedersen 2004, 99-182

[11] Hansen 1983, 301-318.

[12] Hansen 1983, 360-370.

[13] Hansen 1974, 245-248

In addition to the combined cost of living and consumer price index constructed by Svend Aage Hansen, Jørgen Pedersen published a Laspeyres cost of living index for Denmark for 1855-1913. His index is based on 18-33 products in six consumption groups, including rent. He utilised consumer, wholesale and institution prices, mainly from Varde, Odense and Aarhus.[14] Pedersen calculated weights based on people's actual consumption, i.e. quantity of consumed commodities. Four different consumption budgets were calculated. One for the household of unskilled workers in 1879, a second for skilled workers in 1879, a third for rural workers in 1880, and finally one for rural workers in 1897. Based on these budgets Pedersen in fact presented four different cost of living indices according to household income in the Danish provinces.[15]

The main difference between the two cost of living indices by Hansen and Pedersen in over-lapping years is higher volatility in the latter. By splicing the two indices in 1870 we arrive at a combined cost of living and consumer price index for Denmark, covering every year 1815-1913.[16]

2.2 Norway

The price index we use for Norway was constructed on demand from the central bank. It covers the years back to 1516 and is constructed by a traditional Laspeyres approach.[17] It is a mixture of a cost of living index and a consumer price index up to 1959, meaning it does not only reflect market prices but also the costs of providing consumer goods for working class families. From 1959 onwards, it stands as a pure consumer price index.[18]

The series for the period in question in this paper is in fact spliced together from four different indices. The first, constructed by Ola Honningdal Grytten, covers the period 1815-1819.[19] It includes 15 commodities representative for working class families. Most prices are taken from the Bergen and Oslo areas, the two most urban districts in Norway at the time. Most prices are retail prices, allthough, some are wholesale.

The second index, also constructed by Grytten, covers the period 1819-1871. This includes 29 commodities in eight consumption groups 1819-1830 and thereafter 47 commodities in nine consumption groups. It involves most kinds of consumption commodities and activities, accept services. Almost

[14] Pedersen 1930, 313-314.
[15] Pedersen 1930, 189-206.
[16] This has been presented in Grytten 2003, 61-79.
[17] Grytten 2004, 47-98.
[18] NOS 1969, 523-527.
[19] In fact it stretches further back in time, but that is not included in this work.

all observations are monthly or quarterly retail or market prices reported all over the country by governmental decree.[20] The key source for these data is the Professor Dr. Ingvar B. Wedervang's Archive on Historical wages and Prices.[21]

The third and fourth cost of living indices are basically compiled from data on prices and consumption patterns in the Oslo area. The first of these, covering the years from 1871 to 1901, was constructed by Jan Ramstad. It was made up of price data on 55 representative commodities, recorded in the Wedervang Archive.[22] Thereafter, we use the cost of living index from the Statistical Office of Kristiania (Oslo) for the period 1901-1914, including about 70 items.[23] Again all major consumption groups are included in these monthly figures, except for services, which are lacking until 1900 and underrepresented thereafter.

2.3 Sweden

Sweden has a long record of presenting historical price data. The last and probably most impressive contribution when it comes to constructing historical price indices comes from Rodney Edvinsson and Johan Söderberg, who at the request of the Swedish central bank, have published a continuous combined cost of living and consumer price index from 1290-2006.[24] The index is constructed on the basis of an impressive amount of data and put together from sub-indices covering different time spans. Here we basically use the sub-index for the years 1815-1914, which originally stretches back to 1732.

Edvinsson and Söderberg made their index on the basis of data from Lennart Jørberg and Gunnar Myrdal.[25] The data taken from Jørberg basically cover the eighteenth century and early nineteenth century. The data from Myrdal, embodied in a cost of living index for Sweden, extends back to 1830 and is still used by Statistics Sweden.[26] Jørberg's and Myrdal's work have been supplemented with data from Stefan Carlén and Lennart Schön.[27]

As is common for historical cost of living and consumer prices, a Laspeyres approach has been used to calculate the new index. Different weights are

[20] Circular, 4th Royal Norwegian Ministry, January 20th 1816 and Wedervang Archive, file 272.

[21] Grytten 2007, 203-230.

[22] Ramstad 1982, 471-493, Minde and Ramstad 1986, 90-121.

[23] NOS 1978, 518-519.

[24] Edvinsson and Söderberg 2008, 1-42.

[25] Jörberg 1972 and Myrdal 1933.

[26] Statistika Meddelanden 2005.

[27] Carlén 1997 and Schön 1988.

adopted for four time intervals within the 1732-1914 period. The number of commodities included varies between the time spans. For the years of interest in our analysis there are 26 for 1815-1830, 30 for 1830-1870 and finally 31 commodities for 1870-1913. Most observations were made on retail data, although, still some are whole gross or even product prices.[28]

Urban and industrialized areas are over represented. However, they reflect price levels and movements in most of the densely populated districts of Sweden at the time. Thus, we can conclude that also the Swedish price index for the period in question is both valid and reliable.

For the period from 1914 onwards we have chosen to use the national cost of living and consumer price indexes used by Statistics Denmark, Statistics Norway and Statistics Sweden.[29] Both the validity and reliability of these increase over time. From around 1920 they must be regarded as very solid and trustworthy, and from about 1960 as excellent.[30]

2.4 Statistical properties of the time series

Before starting our analysis of the price stability it is important to know the statistical properties of the time series, i.e. whether they are stationary or nonstationary. It is not uncommon for a macroeconomic time series to be nonstationary. A nonstationary time series $\{y_t\}$ do not have the properties of time invariant first and second moments, i.e., the mean $E(y_t)$ and variance $Var(y_t)$ is not constant. Another important property with a stationary time series is that the covariance $Cov(y_t, y_{t\pm s})$ between two time periods t and s depends on the time period between them s and not on the actual time t that the covariance is computed. Investigating possible relationships between two nonstationary time series may lead to results that are spurious.

Looking at the time series using logs in Figure 1 it seems plausible that the variables in levels are nonstationary when the first differences seem to be stationary. Note that the first differences is the inflation rate. To formally test for a unit root we employ the Augmented Dicky-Fuller (ADF) test.[31] The number of lags is chosen as the highest significant lag out of a maximum of seven lags. The test statistics for the entire time span and the sub-periods are reported in Table 1.

[28] Edvinsson and Söderberg 2007, 30-31.

[29] Data provided on request by Statistics Denmark, Statistics Norway and Statistics Sweden.

[30] NOS 1994, 290-293.

[31] Most estimations is this paper is computed using the statistical package *gretl 1.7.5* (Gnu Regression, Econometrics and Time-series Library). In addition we use Stata 10.1 (mainly for the Zivot and Andrews test) and for graphics we use *gnuplot 4.2*.

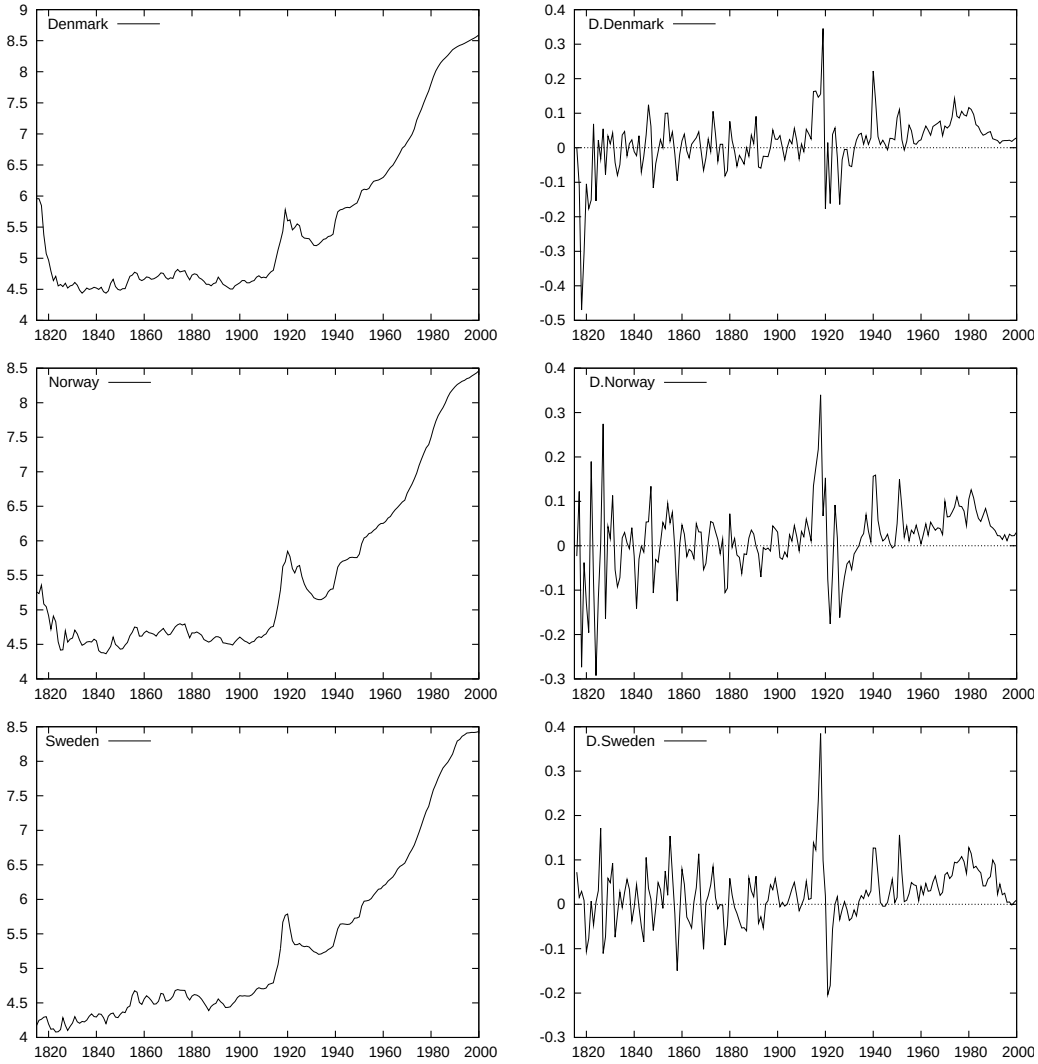

Figure 1: Logarithm of consumer price indices for Denmark, Norway and Sweden 1815–2000 (1900 = 100). In levels (left column) and first differences.

Table 1: Unit root tests

Variable	ADF	No. lags	Critical values 1	5	10	Asymptotic p-value
		Years 1815–1842				
Denmark	-2.029	0	-4.362	-3.592	-3.235	0.560
Norway	-2.237	0	-4.362	-3.592	-3.235	0.451
Sweden	-2.284	0	-4.362	-3.592	-3.235	0.428
D.Denmark	-2.727	0	-2.658	-1.950	-1.600	0.008
D.Norway	-5.312	0	-2.658	-1.950	-1.600	0.000
D.Sweden	-5.075	0	-2.658	-1.950	-1.600	0.000
		Years 1843–1873				
Denmark	-4.025	1	-4.325	-3.576	-3.226	0.008
Norway	-2.290	7	-4.325	-3.576	-3.226	0.439
Sweden	-3.494	1	-4.325	-3.576	-3.226	0.040
D.Denmark	-4.323	1	-2.650	-1.950	-1.602	0.000
D.Norway	-1.995	6	-2.650	-1.950	-1.602	0.044
D.Sweden	-4.954	2	-2.650	-1.950	-1.602	0.000
		Years 1874–1913				
Denmark	0.208	5	-4.242	-3.540	-3.204	0.998
Norway	-1.166	1	-4.242	-3.540	-3.204	0.916
Sweden	-1.837	1	-4.242	-3.540	-3.204	0.687
D.Denmark	-4.284	4	-2.636	-1.950	-1.606	0.000
D.Norway	-4.721	0	-2.636	-1.950	-1.606	0.000
D.Sweden	-4.631	0	-2.636	-1.950	-1.606	0.000
		Years 1914–1945				
Denmark	-2.534	2	-4.316	-3.572	-3.223	0.311
Norway	-2.646	1	-4.316	-3.572	-3.223	0.260
Sweden	-3.302	5	-4.316	-3.572	-3.223	0.066
D.Denmark	-4.073	0	-2.649	-1.950	-1.603	0.000
D.Norway	-2.675	0	-2.649	-1.950	-1.603	0.009
D.Sweden	-2.412	0	-2.649	-1.950	-1.603	0.018
		Years 1946–2000				
Denmark	-1.942	3	-4.139	-3.495	-3.177	0.632
Norway	-2.524	5	-4.139	-3.495	-3.177	0.317
Sweden	-1.659	3	-4.139	-3.495	-3.177	0.770
D.Denmark	-0.876	2	-2.618	-1.950	-1.610	0.337
D.Norway	-0.877	4	-2.618	-1.950	-1.610	0.336

Continued on next page

Table 1 – continued from previous page

Variable	ADF	No. lags	Critical values 1	5	10	Asymptotic *p*-value
D.Sweden	-1.051	2	-2.618	-1.950	-1.610	0.265
		Years 1815–2000				
Denmark	-3.060	1	-4.012	-3.439	-3.139	0.116
Norway	-0.755	6	-4.014	-3.439	-3.139	0.968
Sweden	-0.626	2	-4.012	-3.439	-3.139	0.977
D.Denmark	-4.483	5	-2.589	-1.950	-1.615	0.000
D.Norway	-3.861	4	-2.589	-1.950	-1.615	0.000
D.Sweden	-3.349	6	-2.590	-1.950	-1.615	0.008

Notes: ADF = Augmented Dicky-Fuller test. Number of lags in parenthesis is chosen as the highest significant lag out of a maximum of seven lags. The test includes a constant and a trend. In first differences there are no constant and no trend included.

For the entire time period 1815–2000 the price data in levels are nonstationary and while the first difference, i.e. the inflation, is stationary. This also holds for the subperiods 1815–1842 and 1874–1913. In the years 1843–1873 the price data for both Denmark and Sweden is stationary in levels, while in the years 1914–1945 the data in levels for Sweden is stationary. In the postwar years 1945–2000 neither the data in levels nor the first differences is stationary.

A weakness with the ADF test is that it does not allow for any structural breaks in the series. To allow for this we apply for the entire time span the Zivot and Andrews test procedure[32] as implemented in the `zandrews` command for Stata by Christopher F. Baum.[33] The Zivot and Andrews test allows for one structural break in the time series. The break can be in the intercept, the trend or both. We test for all three types of breaks, and the results are reported in Table 2. The test results for the whole time span give the same overall conclusion as for the ADF for Norway and Sweden. The data for Denmark is stationary when testing for break in trend and intercept and trend. The test identify a break in the data around 1930 for all three countries.

However, if we restrict the data to 1843–1945, the Zivot and Andrew test, when testing for a break in both the intercept and the trend, identify a break in the data for all three countries around 1915. This is also very clear from the representation of the data in Figure 1 both in levels and differences.

[32]Zivot and Andrews 1992.

[33]Baum 2001.

Table 2: Zivot and Andrews unit root test.

Variable	Break	t-statistic	Break year	Critical values	
				1%	5%
Denmark	intercept	−4.515 (2)	1965	−5.43	−4.80
Norway	intercept	−2.975 (1)	1970	−5.43	−4.80
Sweden	intercept	−2.562 (2)	1970	−5.43	−4.80
Denmark	trend	−6.003 (2)	1932	−4.93	−4.42
Norway	trend	−3.588 (1)	1932	−4.93	−4.42
Sweden	trend	−3.385 (2)	1936	−4.93	−4.42
Denmark	both	−6.007 (2)	1930	−5.57	−5.08
Norway	both	−3.614 (1)	1926	−5.57	−5.08
Sweden	both	−3.412 (2)	1929	−5.57	−5.08

Notes: Number of lags in parenthesis is chosen as the highest significant lag out of a maximum of seven lags.

3 Domestic price stability

In order to examine domestic price stability we first take a closer look at the cost of living/consumer price indices for the three countries 1815-2000. These are plotted in Figure 2 below. In order to make the series more comparable we use 1900 as the reference year (1900 = 100) for all indices.

According to the plots it seems as prices kept a relatively stable pattern during the years of the efficient gold standard in the Scandinavian countries from January 1874 till July 1914, indicating a stable pattern of domestic prices in all of the three countries examined here.

The correlation of prices also seems to be significant. Hence, cross-border price stability also seems to have been present. However, this needs further examination before we can draw strong conclusions. The approach can be twofold: one has a short term-perspective, while the other has a long-term perspective.

3.1 Long-term perspective on price stability

In order to map price developments over time it will be of interest to split long-term and short-term price fluctuations. This can be done by different smoothing techniques. Here we use the so-called Hodrick-Prescott filter (HP-filter), which has been commonly used with historical time series.

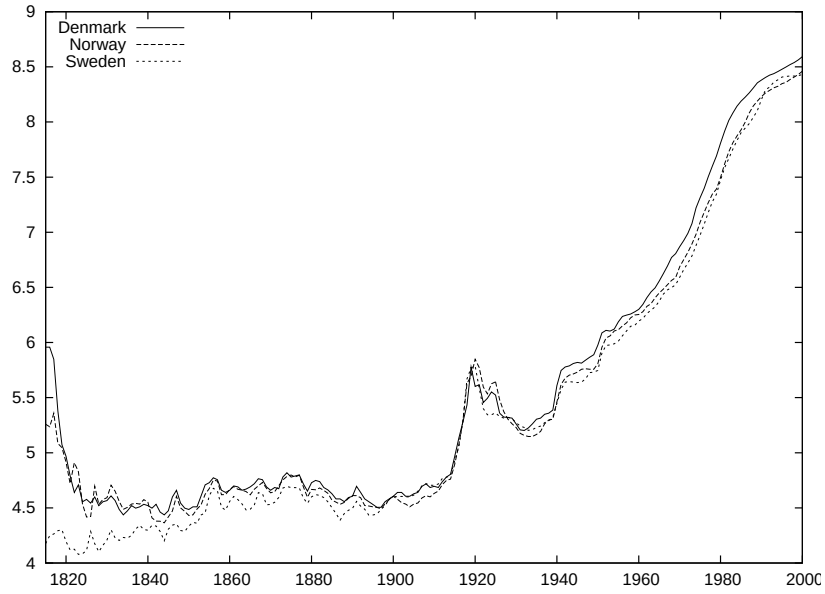

Figure 2: Consumer price indices for Denmark, Norway and Sweden 1815–2000 (1900 = 100).

The HP-filter is an algorithm for finding smoothed values, i.e., polynomial trends, of time series. The filter separates an observed time series, in this case prices, p at observation point t (here time) into a smoothed or a trend component, g_t, and a cyclical component, c_t, as stated in equation (1):

$$p_t = g_t + c_t \tag{1}$$

The cyclical component will here be a measure of the strength of the cycle. The objective function of the filtered series will have the form stated in equation (2):

$$\min \quad \sum_{t=1}^{T}(y_t - g_t)^2 + \lambda \sum_{t=2}^{T-1}[(g_{t+1} - g_t) - (g_t - g_{t-1})]^2. \tag{2}$$

Here T is the number of samples and λ is the smoothing parameter, specifying the smoothness of the trend. A normal λ-value for annual data would be 100, when 1,600 respectively 14,400 are regarded as normal values for quarterly and monthly data sets. Thus, we apply $\lambda = 100$ in the present analysis. The smoothed trends of price developments for Denmark, Norway and Sweden 1815-2000 are plotted in Figure 3 below.

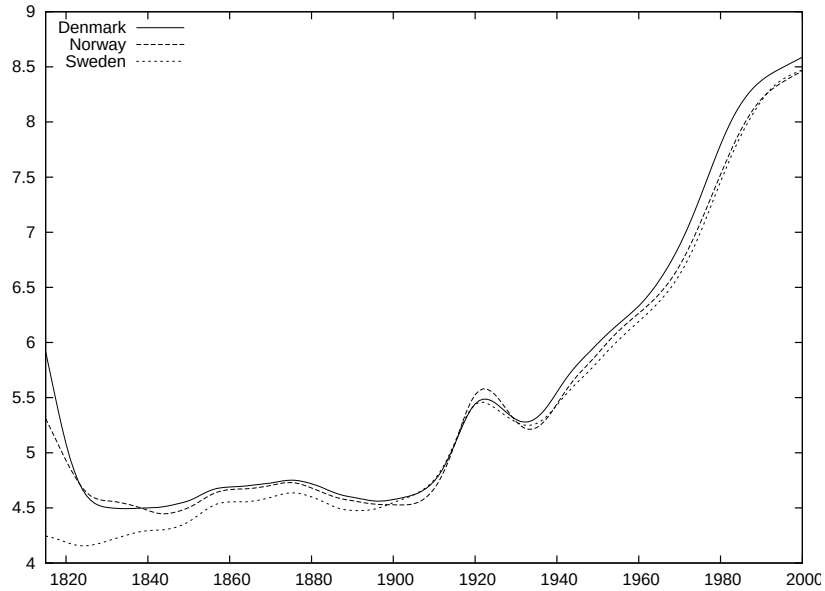

Figure 3: Consumer price indices for Denmark, Norway and Sweden 1815–2000 (1900 = 100). HP-filtered ($\lambda = 100$).

Using a HP-filter in order to smooth the series we find that in a long-term view prices seem to have been quite stable from the mid-1850s till the outbreak of World War I. In other words, prices were most stable during the heydays of both the silver and the gold standard. Prices were also relatively stable from the 1840s to the introduction of gold in 1874, when inflation was stable during the post-World War II-era until the early 1970s.[34]

In order to examine domestic long-term price stability we will also use other simple quantitative measurements. The first is mean rate of inflation (MRI), which reports the average inflation rate for certain periods, as stated in equation (3):

$$MRI = \frac{1}{N} \sum_{t=1}^{N} \Delta p_t. \tag{3}$$

Here t denotes the actual number of a certain observation, N denotes the total number of observations and $\Delta p_t = p_t - p_{t-1}$ where $p_t = \ln P_t$ and $p_{t-1} = \ln P_{t-1}$.

Secondly, we look at the inflation rate as a log-linear function within

[34] This is basically reflected, but not at all well quantitatively documented in standard text-books on Scandinavian economic history, see e.g. Schön 2001, Johansen 1987 and Hodne 1983.

Table 3: Long-term domestic price stability.

	1815–1842	1843–1873	1874–1913	1914–1945	1946–2000	1815–2000
			Denmark			
MRI	-0.053	0.008	0.000	0.032	0.050	0.014
LLRI	-0.041	0.008	-0.002	0.013	0.060	0.019
R^2	0.560	0.541	0.062	0.240	0.974	0.696
			Norway			
MRI	-0.033	0.012	0.000	0.031	0.050	0.017
LLRI	-0.027	0.010	-0.003	0.006	0.057	0.019
R^2	0.646	0.635	0.158	0.047	0.976	0.712
			Sweden			
MRI	0.006	0.011	0.002	0.027	0.051	0.023
LLRI	0.005	0.012	0.003	0.008	0.059	0.021
R^2	0.229	0.630	0.102	0.098	0.975	0.808

periods. In doing so we estimate regression coefficients according to a log-linear equation. By doing this we obtain the exponential growth trend of prices during time-spans, here called the log-linear rate of inflation ($LLRI$), according to equation (4):

$$P_t = \beta_0 e^{\beta_1 t} + \varepsilon_t \tag{4}$$

where $LLRI = \beta_1$ and P_t is the price index in levels. Further, β_0 is a constant and ε_t is the disturbance-term.

The results of the estimates for the MRI and LLRI are presented in Table 3. They confirm that both the inflation rate and the trend rate of inflation were quite modest and close to zero during heydays of the Scandinavian gold standard period 1874-1913/1914.[35] In addition, prices kept at a significantly more stable level during these years than any other period investigated here.

Thus, on the basis of the calculations presented in Table 3, we can conclude that long-term domestic price stability was quite good during the efficient gold standard era of the Scandinavian countries.

3.2 Short-term domestic price stability

To examine the short-term price fluctuations we use the mean rate of price change (MRPC), which report the relative changes of prices in absolute terms. Hence, in our first approach in order to investigate short-term price

[35] Talia 2004b.

stability wee look at the mean of price changes, where inflation and deflation does not annul each other as they do in the MRI-calculations. Equation (5) illustrates how MRPC is found:

$$MRPC = \frac{1}{N}\sum_{t=1}^{N}\sqrt{\Delta p_t^2}. \tag{5}$$

To map the strength of the fluctuations from the trend component we calculate the standard deviations of the observed price value from the corresponding HP-trend (SDHPT) at the same point. This is not the same as a general standard deviation, which is calculated as standard deviation from the mean value. In order to make clear the approach in this paper, relative standard deviation from the HP-trend is stated in equation (6):

$$SDHPT = \sqrt{\frac{1}{N}\sum_{t=1}^{N}(p_t - p_t^{HP})^2}. \tag{6}$$

Here p^{HP} denotes the HP-trend at observation t, which is a time parameter (both p_t and p_t^{HP} are the natural logarithm of the variable). If the outcomes from these calculations show modest standard deviations from trend during the gold standard period compared to other periods, we can conclude that short-term price stability was relatively good.

Sub-periods In order to carry out these estimations, we have divided our series into sub-periods again. The first one covers the years 1815-1842, which includes the aftermath of the Napoleonic wars and the turbulent times until monetary stability was restored for all the three Scandinavian countries in 1842.[36] The second period covers the efficient silver standard era for the Scandinavian economies 1843-1873.[37] The third period is the key period of this paper 1874-1913, the heydays of the international gold standard in the Scandinavian countries.[38] The fourth period stretches from 1914 till 1945 and includes two world wars and turbulent times for the international economy.[39] Thereafter we look at the post-war era 1946-2000, a time of social-democratic order in the Scandinavian countries.[40]

The results of the calculations are reported in Table 4, and they give fairly clear evidence of price stability in the efficient gold standard era. The table

[36] Eitrheim 2005, 1-17.
[37] Keilhau 1952.
[38] Øksendal 2007.
[39] Bordo 1986, Klovland 1998, 309-344.
[40] Moene and Wallerstein 2006, 18-35.

Table 4: Short-term domestic price stability.

	1815–1842	1843–1873	1874–1913	1914–1945	1946–2000	1815–2000
			Denmark			
MRPC	0.081	0.044	0.032	0.075	0.051	0.054
SDHPT	0.099	0.058	0.051	0.106	0.026	0.069
			Norway			
MRPC	0.096	0.044	0.030	0.081	0.050	0.057
SDHPT	0.097	0.057	0.048	0.120	0.029	0.072
			Sweden			
MRPC	0.048	0.052	0.029	0.065	0.051	0.049
SDHPT	0.054	0.062	0.051	0.131	0.029	0.069

confirms that price stability was higher during the efficient gold standard period 1874-1913. Admittedly the deviations from the HP-trend were smaller after World War II. However, this was due to a period of constantly high and more or less stable inflation, rather than price stability. Thus, we have to split between price stability and inflation persistency.

4 Inflation persistence

So far we have looked at different measures on domestic price stability. In this section we take a new approach by looking at inflation persistence. In the past decade this have been an important topic in macroeconomics.[41] There are different definitions of inflation persistence in the economics literature. E.g. Batini and Nelson distinguish between three types.[42]

1 Positive serial correlation in inflation

2 Lags between *systematic* monetary policy actions and their (peak) effect on inflation

3 Lagged responses of inflation to non-systematic policy actions (i.e. policy shocks)

Before investigating inflation persistence in detail we start by looking at mean inflation in a time period by regressing the inflation on a constant only. The standard error of the regression is an estimate of the standard deviation of the inflation.

$$\pi_t = \mu + \varepsilon_t \tag{7}$$

[41] Benati 2008, 1004.

[42] Batini and Nelson 2001, 383.

where $\pi_t = \Delta p_t$.

In studying the inflation persistence we estimate an univariate AR process for the inflation time series.

$$\pi_t = \mu + \sum_{j=1}^{k} \alpha_j \pi_{t-j} + \varepsilon_t. \tag{8}$$

We assume that the error term ε_t is serially uncorrelated, but possibly heteroscedastic. As a measure of the degree of inflation persistence, denoted by ρ, we use the sum of the estimated lagged autoregressive coefficients[43]

$$\rho \equiv \sum_{j=1}^{k} \hat{\alpha}_j. \tag{9}$$

Equation (8) above can be rewritten as

$$\pi_t = \mu + \rho \pi_{t-1} + \sum_{j=1}^{k-1} \beta_j \Delta \pi_{t-j} + \varepsilon_t. \tag{10}$$

The inflation persistence is still defined as $\rho = \sum \alpha_j$, and its value is given by the estimate of ρ, i.e. $\hat{\rho}$. The parameters β_j are transformations of the parameters α_j in Equation (8). A nice feature of Equation (10) is the value of ρ. If $\rho = 1$ the time series has a unit root and if $|\rho| < 1$ the data generating process of the inflation is stationary.

The estimations results of the specifications in Equations (7) and (10) are given in Tables 5, 6 and 7 for Denmark, Norway and Sweden respectively. To decide upon the number of lags k to include in the estimation we have used the Akaike information criteria (AIC) and the Schwarz criterion (SC) with a maximum of seven lags.

For the Scandinavian countries, mean inflation was lowest during the period of the classical gold standard and the existence of the Scandinavian Currency Union (1874–1913) where mean inflation was zero or close to zero (Model 1 in the Tables). Looking at the estimates of the persistence parameter ($\hat{\rho}$) shows that all three countries experiences a dramatic increase in the inflation persistence after the breakdown of the currency union. In fact, our results are in line with Benati, who also shows that for several countries including Sweden "statistical persistence to have been entirely absent from the pre-1914 world, and to have appeared only after the collapse of the classical gold standard."[44] Further, adding this together with the estimates of Model

[43] Andrews and Chen 1994.

[44] Benati 2008, 1042.

Table 5: Estimates of mean inflation (*Model 1*) and inflation persistence (*Model 2*) for Denmark 1815–2000.

	1815–1842	1843–1873	1874–1913	1914–1945	1946–2000	1815–2000
			Model 1			
$\hat{\mu}$	-0.0528	0.0080	0.0000	0.0325	0.0504	0.0142
s.e.	0.0231	0.0102	0.0063	0.0190	0.0046	0.0059
$\hat{\sigma}$	0.1202	0.0567	0.0401	0.1074	0.0340	0.0797
			Model 2			
$\hat{\rho}$	0.3406	0.0322	0.0255	0.3818	0.8003	0.5218
s.e.	0.1543	0.2218	0.1947	0.2253	0.0992	0.0047
R^2	0.4278	0.1867	0.0884	0.0901	0.6178	0.2040
adj. R^2	0.3007	0.1286	0.0391	0.0274	0.5953	0.1859
$\hat{\sigma}$	0.0596	0.0529	0.0393	0.1060	0.0217	0.0606
$k-1$ lags	3	1	1	1	2	3

Table 6: Estimates of mean inflation (*Model 1*) and inflation persistence (*Model 2*) for Norway 1815–2000.

	1815–1842	1843–1873	1874–1913	1914–1945	1946–2000	1815–2000
			Model 1			
$\hat{\mu}$	-0.0326	0.0121	-0.0001	0.0307	0.0496	0.0173
s.e.	0.0244	0.0098	0.0061	0.0193	0.0046	0.0058
$\hat{\sigma}$	0.1270	0.0547	0.0385	0.1091	0.0341	0.0788
			Model 2			
$\hat{\rho}$	-0.3656	0.0899	0.2468	0.5681	0.6194	0.5811
s.e.	0.3064	0.2256	0.1938	0.1665	0.1153	0.1130
R^2	0.0616	0.0543	0.0850	0.3586	0.4187	0.2304
adj. R^2	-0.0238	-0.0133	0.0355	0.3143	0.3963	0.1987
$\hat{\sigma}$	0.1296	0.0550	0.0378	0.0903	0.0265	0.0653
$k-1$ lags	1	1	1	1	1	6

Table 7: Estimates of mean inflation (*Model 1*) and inflation persistence (*Model 2*) for Sweden 1815–2000.

	1815–1842	1843–1873	1874–1913	1914–1945	1946–2000	1815–2000
			Model 1			
$\hat{\mu}$	0.0059	0.0111	0.0025	0.0268	0.0508	0.0230
s.e.	0.0121	0.0119	0.0059	0.0187	0.0049	0.0048
$\hat{\sigma}$	0.0629	0.0661	0.0374	0.1057	0.0362	0.0650
			Model 2			
$\hat{\rho}$	-0.302384	-0.5252	0.2534	0.5610	0.7041	0.4366
s.e.	0.2833	0.2912	0.1706	0.1457	0.1310	0.0729
R^2	0.0944	0.3248	0.1615	0.4907	0.4107	0.2767
adj. R^2	0.0121	0.2498	0.1162	0.4556	0.3761	0.2687
$\hat{\sigma}$	0.0635	0.0572	0.0352	0.0780	0.0286	0.0558
$k-1$ lags	1	2	1	1	2	1

1 in the Tables and the graphical representation of the inflation rates in Figure 1, it seems clear that less persistence is corresponding to less variability in the inflation, cfr. the quotation from Willis above.

Rolling estimates of $\hat{\rho}$ Instead of defining the sub-period based on historical events we adopt the method of rolling regressions. That is, we estimate the persistence parameter ρ in a time moving sub-sample of 15 years. The estimates of ρ along with a 95% confidence interval are presented in Figures 4, 5 and 6 for the countries that we investigate. The rolling estimates confirm our analysis above. There is a marked shift in the persistence parameter at the outbreak of World War I. During the classical gold standard both the level and the variability of the persistence parameter ρ is lower than after 1914.

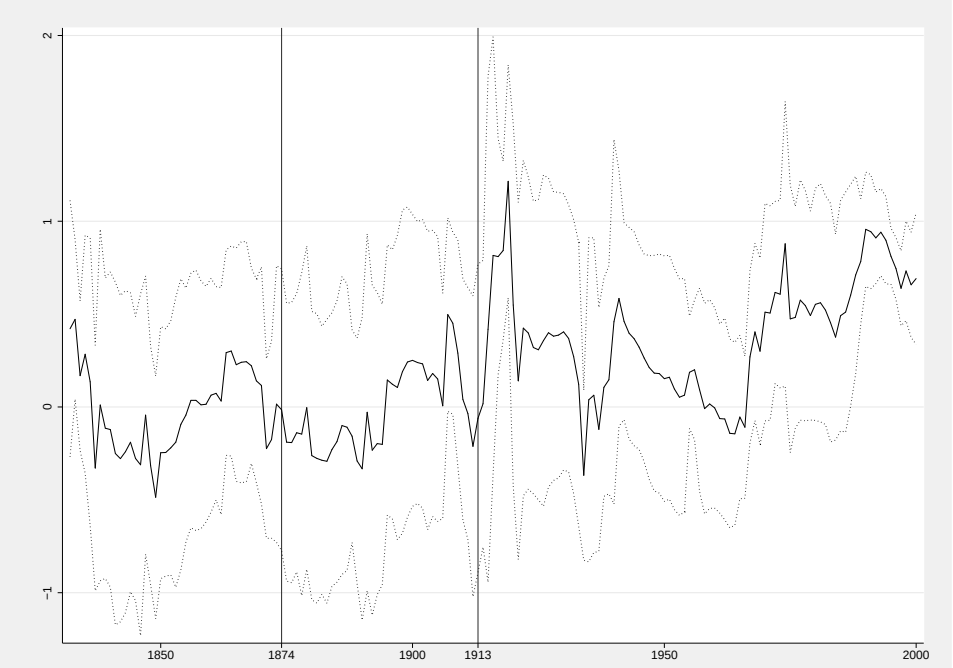

Figure 4: Rolling estimates and the 95% CI of the persistence parameter $\hat{\rho}$ for Denmark 1815–2000. Window size 15 years.

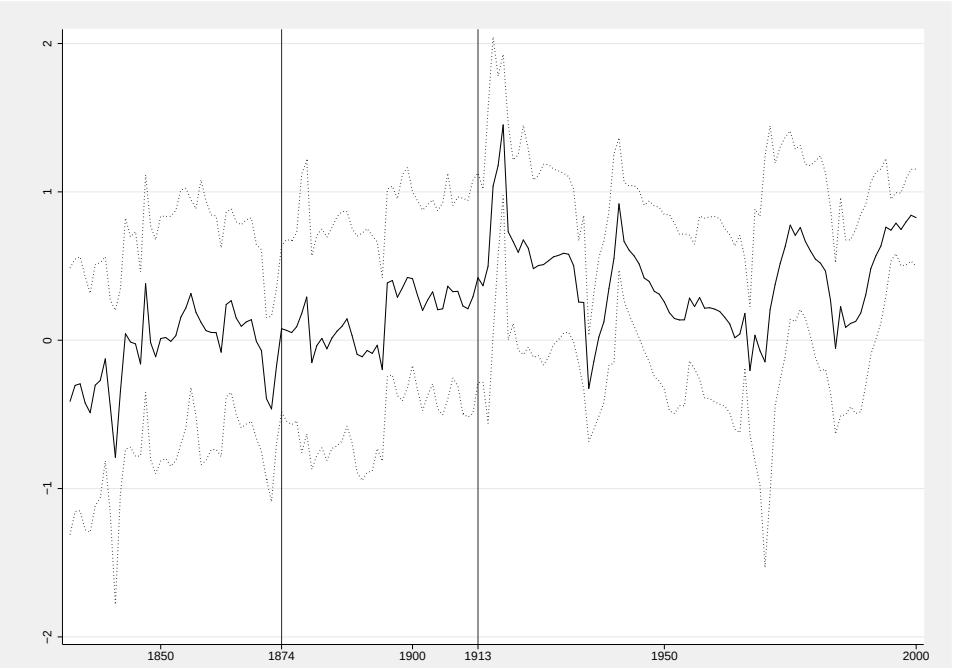

Figure 5: Rolling estimates and the 95% CI of the persistence parameter $\hat{\rho}$ for Norway 1815–2000. Window size 15 years.

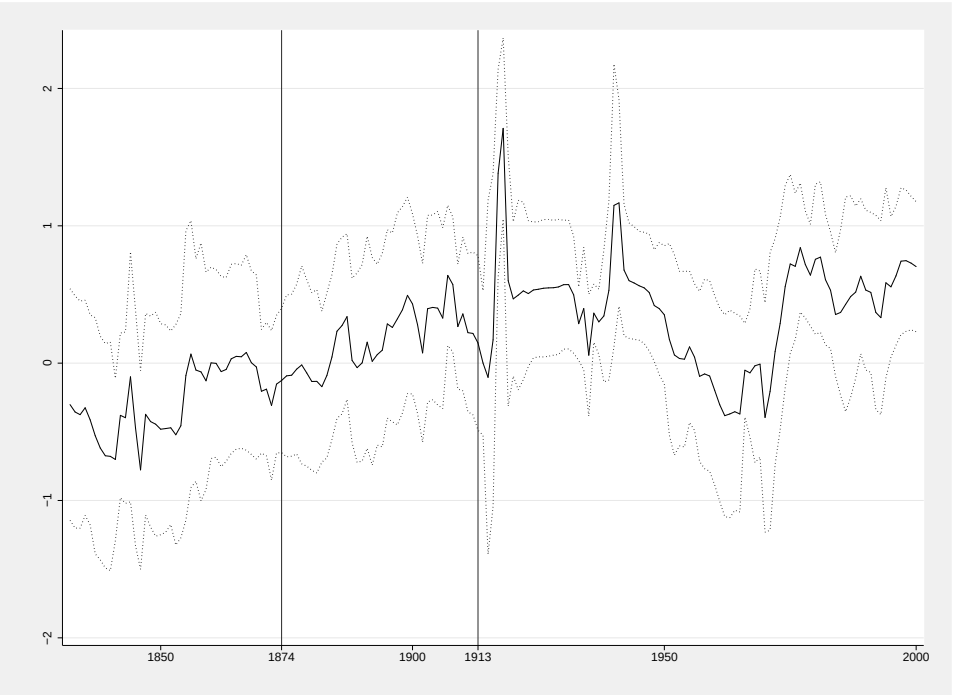

Figure 6: Rolling estimates and the 95% CI of the persistence parameter $\hat{\rho}$ for Sweden 1815–2000. Window size 15 years.

5 Cross-border price stability

Also cross-border price stability can be seen in the long- and the short run. Here we again investigate both relationships in order to give light to how effective the Scandinavian adoption of the international gold standard from the 1870s was on price stability.

From Figure 2 we read that prices seem to have a fairly high degree of co-movement in the gold standard era from 1874 till the outbreak of World War I in July/August 1914. In order to have a closer look at the years in question we plot the graphs for this period in particular in Figure 7.

According to Figure 7, prices in the three countries moved uniformly 1874-1914, both in the long-term and in the short-term. Inflation and deflation was seldom more than five per cent and never more than ten per cent. The co-movement of prices in the three countries confirms cross-border price stability.

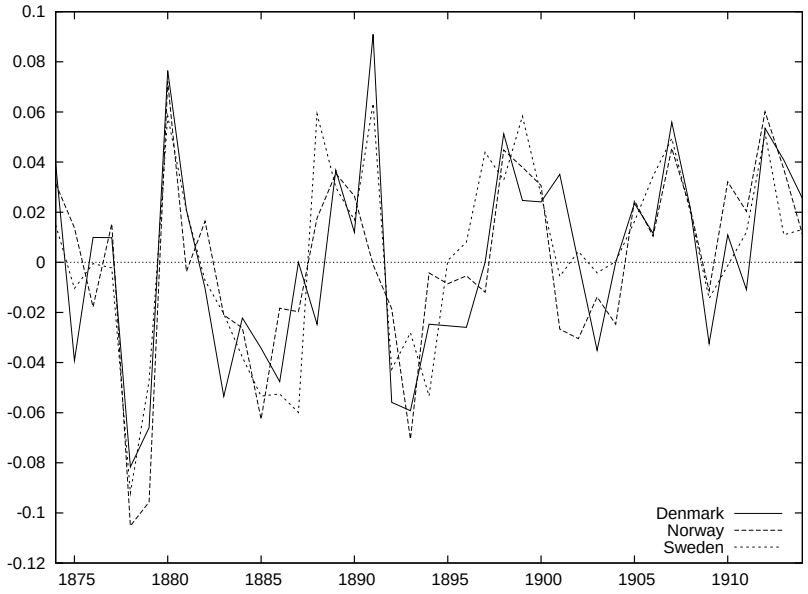

Figure 7: Annual inflation rates in Denmark, Norway and Sweden 1874–1914.

5.1 Long-term price stability

The inflation rates during the period in question can tell us a lot about cross-border price stability. Thus, we have compared the average or mean rates of inflation (MRI) for the three countries during the different sub-periods. The results are shown in Figure 8. The chart clearly reveals that over-all inflation was close to zero in all three countries 1874-1913, and significantly closer than in any other sub-period.

In addition the inflation rates were also very similar during the period of the effective gold standard. Thus, it is obvious to conclude that long-term cross border price stability was predominant for the Scandinavian economies from the introduction and adoption of the gold standard in January 1874 until the outbreak of World War I in July/August 1914. What then about short-term cross-border price stability?

5.2 Short-term price stability

If short-term cross-border price stability was strong during the gold standard period one would expect high degree of co-movement of prices and minor deviations of inflation and deflation between the countries. Hence, wee seek to examine if this was the case.

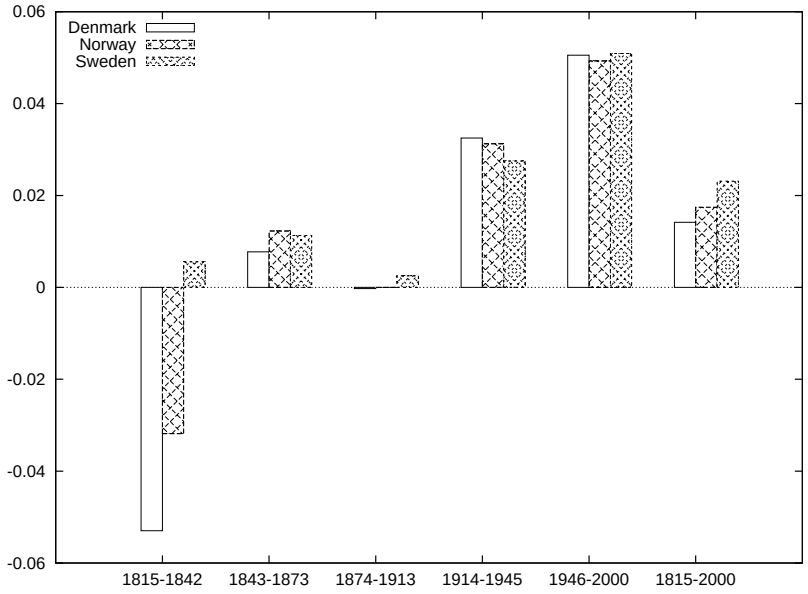

Figure 8: Mean rates of inflation for Denmark, Norway and Sweden 1815-2000.

Firs we calculate correlation coefficients for price-movements between the three countries. According to Figure 3 the long-term co-movements of prices were very good for Denmark, Norway and Sweden, except for a different development of prices in Sweden until the early 1840s. By looking at the correlation of price deviations from the HP-filtered trend we find a measure of co-movements of prices around their polynomial trends. This is done according to equation (11):

$$corr(p_i, p_j) = corr(p_{it} - p_{it}^{HP}, p_{jt} - p_{jt}^{HP}). \tag{11}$$

Here i and j denotes different countries. Correlation matrices are made for the three countries reporting all sub-period.

Secondly, we calculate the standard deviations. More precisely wee look at relative annual standard deviations of inflation from the mean values for the three countries (SDM), and examine if the efficient gold standard period made up any difference. This is done according to equation (12):

$$SDM = \frac{1}{N}\sum_{t=1}^{N}\sqrt{\frac{1}{Z}\sum_{i=1}^{Z}(\Delta p_{it} - \Delta p_t^m)^2}. \tag{12}$$

In this Equation (12) m denotes the mean value (over countries) of prices, i

the number of the country the observation is taken from, when Z is the total number of countries in the sample.

The results from the latter calculations are reported in Tables 8 and 9. Table 8 reveals that with the exception for unsatisfactory Swedish correlation with Norway and Denmark during the period 1815-1842, co-movements of prices were quite high. For the epoch of efficient gold standard the correlation coefficients are stunning in as much as they are close to or over 0.9 for all observations.

Also, the correlations are also quite impressive for the efficient silver standard period 1843-1873. These high correlations of short-term price movements around the polynomial trend, give substantial evidence of short-term cross-border price stability in the three Nordic countries, Denmark, Norway and Sweden, all members of the Scandinavian Currency Union at the time.

Table 9 reports average relative standard deviations of inflation from the cross-border mean values by sub-periods. Again, we find that the standard deviations were at their lowest during the efficient gold standard period of the countries under investigation.

Admittedly, after World War II we find average standard deviations, which are at the same low level. However, this must be explained by a social-democratic planning regime and a continuously more globalized world economy, in which the Scandinavian countries took part.[45] When it comes to centralized economic planning, they were the leading economies in the capitalist world.[46] Also, there was a steady high inflation trend in this epoch, making it less comparable with the other sub-periods. In the more or less liberal-world era before World War II, the international gold standard years 1874-1913 saw lower standard deviations from mean inflation, and thus, confirms that short-term cross-border price stability was high during this period.

The developments of the calculated standard deviations are shown annually in Figure 9. This plot gives us a clear indication of significant cross-border price stability during the gold standard era of investigation here. Both the annual deviations 1815-2000 and the HP-filtered trend are reported in the chart.

Price stability clearly was lowest during the periods of monetary chaos 1815-1842 and 1914-1945 and high under the silver and gold standard years, respectively 1843-1873 and 1874-1913, along with the post World War II period. This development definitely reflects international trends in price history.[47] However, price stability during the post-war era was, as stated

[45] Schenk 1999, 105-121.

[46] Damsgaard Hansen 2001, 340-348.

[47] Eichengreen 1997.

Table 8: Correlation matrix on price deviations from HP-filtered trend.

1815–1842:	Denmark	Norway	Sweden	
	1.0000	0.4087	0.2120	Denmark
		1.0000	0.1750	Norway
			1.0000	Sweden
1843–1873:	Denmark	Norway	Sweden	
	1.0000	0.9055	0.7711	Denmark
		1.0000	0.7903	Norway
			1.0000	Sweden
1874–1913:	Denmark	Norway	Sweden	
	1.0000	0.8885	0.9312	Denmark
		1.0000	0.9228	Norway
			1.0000	Sweden
1914–1945:	Denmark	Norway	Sweden	
	1.0000	0.8703	0.8300	Denmark
		1.0000	0.8841	Norway
			1.0000	Sweden
1946–2000:	Denmark	Norway	Sweden	
	1.0000	0.5636	0.5785	Denmark
		1.0000	0.5803	Norway
			1.0000	Sweden
1815–2000:	Denmark	Norway	Sweden	
	1.0000	0.7258	0.6836	Denmark
		1.0000	0.7259	Norway
			1.0000	Sweden

5% critical values (two-tailed): 1815–1842: 0.3739 for $n = 28$; 1843–1873: 0.3550 for $n = 31$; 1874–1913: 0.3120 for $n = 40$; 1914–1945: 0.3494 for $n = 32$; 1946-2000: 0.2656 for $n = 55$; 1815–2000: 0.1439 for $n = 186$.

Table 9: Average standard deviations from annual mean values of inflation.

Years	s.d.
1815–1842	0.058813
1843–1873	0.023312
1874–1913	0.013307
1914–1945	0.031414
1946–2000	0.012407
1815–2000	0.024489

previously, more a state of inflation persistency than price stability. Also, when inflation was impressively persistent 1952-1973, this seem to have ended with significantly higher inflation rates in the 1970s followed by lower inflation from the 1990s. Again, the development of consumer prices in the Scandinavian countries mirrors the international picture, despite a huge improvement in the terms of trade for the petroleum-dependent Norwegian economy.[48]

6 Conclusions

The present paper offers an examination of monetary policy and inflation dynamics, defined as price stability and inflation persistence in the three Scandinavian countries, Denmark, Norway and Sweden under the effective international gold standard regime. For these three countries this lasted from its Nordic introduction in January 1874 to the outbreak of World War I in July/August 1914.

In January 1877 the Scandinavian Currency Union became effective, meaning that the three countries adopted similar key currencies, the Danish, Norwegian and Swedish krone, which had the same gold value and were mutually legal tender in all three countries. This should in theory ensure price stability and inflation persistence for and between the Scandinavian countries.

In order to examine the inflation dynamics of the gold standard, this paper gives a basically quantitative analysis of domestic and cross-border short and long term price stability along with inflation persistence.

The paper build its analysis on existing and new cost of living/consumer price indices for the three countries. The most important conclusions are that both domestic and cross-border price stability in the long and short

[48] Hodne and Grytten 2002, 285-300.

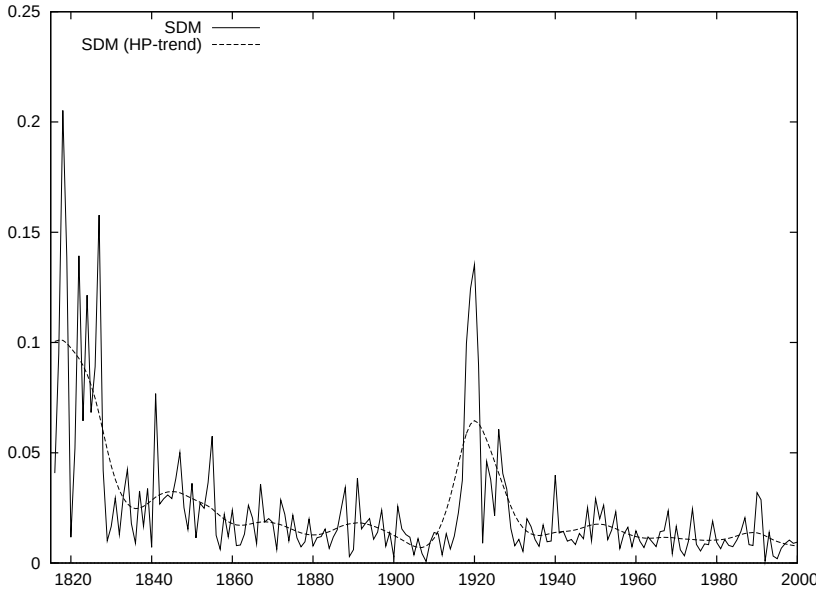

Figure 9: Standard deviations of inflation from mean values for Denmark, Norway and Sweden.

run were predominant during the efficient gold standard period. In fact the years of the efficient gold standard 1874-1914 stand as the period with the highest price stability, both domestically and cross-border, during the last two centuries. The analysis also gives evidence of practically no inflation persistence during the period. In this respect the gold standard and the monetary policy connected to this monetary regime should be considered a success, despite its failure to maintain financial stability in times of great shocks to the economy.

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