

Grytten, Ola Honningdal; Hunnes, Arngrim

**Working Paper**

## The Historical Connection Between Short Term Output and Prices in a Small Open Economy

Working Paper, No. 2009/21

**Provided in Cooperation with:**

Norges Bank, Oslo

*Suggested Citation:* Grytten, Ola Honningdal; Hunnes, Arngrim (2009) : The Historical Connection Between Short Term Output and Prices in a Small Open Economy, Working Paper, No. 2009/21, ISBN 978-82-7553-526-7, Norges Bank, Oslo, <https://hdl.handle.net/11250/2497620>

This Version is available at:

<https://hdl.handle.net/10419/209937>

**Standard-Nutzungsbedingungen:**

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

**Terms of use:**

*Documents in EconStor may be saved and copied for your personal and scholarly purposes.*

*You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.*

*If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.*



<https://creativecommons.org/licenses/by-nc-nd/4.0/deed.no>

2009 | 21

# Working Paper

Norges Bank's bicentenary project

## The historical connection between short term output and prices in a small open economy

*by Ola Grytten and Arngrim Hunnes*

**Working papers fra Norges Bank, fra 1992/1 til 2009/2 kan bestilles over e-post.**

servicesenter@norges-bank.no

eller ved henvendelse til:

Norges Bank, Abonnementservice

Postboks 1179 Sentrum

0107 Oslo

Telefon 22 31 63 83, Telefaks 22 41 31 05

Fra 1999 og fremover er publikasjonene tilgjengelig på [www.norges-bank.no](http://www.norges-bank.no)

Working papers inneholder forskningsarbeider og utredninger som vanligvis ikke har fått sin endelige form. Hensikten er blant annet at forfatteren kan motta kommentarer fra kolleger og andre interesserte. Synspunkter og konklusjoner i arbeidene står for forfatterens regning.

**Working papers from Norges Bank, from 1992/1 to 2009/2 can be ordered by e-mail:**

servicesenter@norges-bank.no

or from Norges Bank, Subscription service

P.O.Box. 1179 Sentrum

N-0107Oslo, Norway.

Tel. +47 22 31 63 83, Fax. +47 22 41 31 05

Working papers from 1999 onwards are available on [www.norges-bank.no](http://www.norges-bank.no)

Norges Bank's working papers present research projects and reports (not usually in their final form) and are intended inter alia to enable the author to benefit from the comments of colleagues and other interested parties. Views and conclusions expressed in working papers are the responsibility of the authors alone.

---

ISSN 1502-8143 (online)

ISBN 978-82-7553-526-7 (online)

# The historical connection between short term output and prices in a small open economy

Ola Grytten\*      Arngrim Hunnes†

October 29, 2009

## Abstract

According to a Keynesian view, short term output fluctuations are normally demand side led. Since prices reflect demand, they should mirror output fluctuations. Thus, prices and output are expected to move in the same direction in the short run. The present paper investigates the historical co-movements of output and prices for a small open raw material based economy, in this case Norway 1830–2006. We find little evidence of a positive relationship. On the contrary, we rather find negative correlations between the two variables, indicating that supply side shocks through the foreign sector were more important for historical business cycles in Norway than assumed hitherto.

**JEL codes:** E31, E32, N10, N13, N14

**Keywords:** Business cycles; Output; Small open economy; Price fluctuations.

## 1 Problem defined

A central assumption behind modern inflation targeting as means of monetary policy is that the inflation rate reflects the pressure in the economy in the way that high inflation rates should mirror high demand and thus expansion in the economy, when low inflation rates should normally mirror low demand and thereby relative contraction in the economy. However, due to substantial supply side shocks, i.e. considerable increase in the productivity level, along with the imports of low cost labor and low cost products, an over

---

\*Department of Economics, Norwegian School of Economics and Business Administration (NHH), Helleveien 30, N-5045 Bergen, Norway. Phone: +47 55 95 93 45. E-mail: [ola.grytten@nhh.no](mailto:ola.grytten@nhh.no)

†Department of Economics and Business Administration, University of Agder (UiA), N-4604 Kristiansand, Norway. E-mail: [arngrim.hunnes@uia.no](mailto:arngrim.hunnes@uia.no)

heated economy with significant financial bubbles was not reflected in high inflation rates during the last decade. The notion of corresponding inflation and output fluctuations has also been a central assumption in economic history writing in line with the empirical findings of Nicolai Kondratiev, who mapped long cycles in the economy by price series and John Maynard Keynes who explained historical business cycle downturns in general by negative shifts in aggregated product demand.<sup>1</sup> The deflation of the 1930s is supposed to reflect this lack of demand. The present paper deals with the possible historical co-movement between prices and output in a small, open, raw material based economy, more precisely Norway. Most writers on Norwegian economic history seem to agree that short term output fluctuations have been demand side led, when most will agree that it is normally supply-side led in the long run.<sup>2</sup> However, very little has been done in order to test the relationship between Norwegian prices and output historically. Thus, in this paper we try to examine if there historically has been any empirical correspondence between short-term price movements and output volumes in the small, open raw-material based economy of Norway. Both annual movements and business cycles are investigated. Positive co-movement between the two variables indicates that the business cycle historically most often is demand side driven, when negative co-movement would indicate that the business cycle historically is more likely to be supply side led. In fact, the latter is what we somewhat surprisingly basically find during the twentieth century and until present days.

## 2 Theoretical background

It is theorized that in the longer span the output from an economy will basically depend on the production possibilities or production barriers within the economy and the possibility of exchange of goods and services with other economies, i.e. international trade. Using a supply side approach, output can be described by the production function

$$Y = F(C, L, N) + \varepsilon. \quad (1)$$

This means that output,  $Y$ , from an economy in the long run is a function,  $F$ , of input of capital,  $C$ , labor,  $L$ , and natural resources,  $N$ . Empirical studies reveal that quantitative changes in these parameters cannot fully explain economic growth. Hence, a residual factor,  $\varepsilon$ , has to be added in order to account for all factors of growth.<sup>3</sup> This residual is often considered as total factor productivity (TFP), which is the qualitative changes in growth

---

<sup>1</sup>Kondratiev 1926, 573-609, Keynes 1936, 23-34.

<sup>2</sup>Sejersted 1973, Hodne 1983, Bergh 1983, Furre 1991.

<sup>3</sup>Abramowitz 1956, 5-23.

variables and in the organization of these, e.g. new technology, infrastructure and institutional factors.

In the short run output fluctuations are by Keynesians assumed to move within the limits of the production barriers of the economy. In other words, short-term output fluctuations reflect the degree of production possibility utilization. This utilization will according to conventional Keynesian theory depend on the demand side of the economy, where the power of demand decides the level of value creation within the production barriers. Thus, in the short run output is a function of demand,

$$Y = F(D). \quad (2)$$

Since the output barriers are stable in the short run, it is assumed that a short term positive shift in the demand curve causes prices to increase. Thus, the price level,  $P$ , is a function of demand when supply is held constant, as is reasonably to assume in the short term.

$$P = F(D) \quad (3)$$

As seen from equation (2) and (3) both prices and output are seen as functions of demand. They are also believed to move in the same directions versus demand, i.e. upwards in response of positive demand shifts and downwards in response of negative demand shifts. Hence, price movements should in general reflect short-term output cycles, which are normally believed to be demand-side led.

According to Keynesian theory the total demand side in an economy is made up by private consumption,  $C$ , public expenditures,  $G$ , investments,  $I$ , and export surplus  $X - M$ . Total demand can in other words be quantified as the expenditure side of the gross domestic product.<sup>4</sup>

$$D = Y = C + G + I + (X - M). \quad (4)$$

Operationally this means that price movements,  $dP$ , can be estimated as a function of GDP-movements,  $dY$ :

$$dP = F(dY) \quad (5)$$

We do not suggest that output is the only decisive short run factor for prices. The picture is far more complicated. However, prices and output should be correlated.

### 3 Research

Surprisingly little has been done in order to examine the historical and empirical relationship between output and prices also in the international

---

<sup>4</sup>Peden 1987, 82–96.

arena. Admittedly, it can easily be illustrated e.g. that prices fell during the long depression from the mid 1870s till the late 1880s, during the post-war depression in the 1920s and during the great depression in the 1930s.<sup>5</sup> In fact these examples of falling output and prices have given name to the term depression.

Nevertheless, it is not at all difficult to point out opposite. Prices tended to fall also during years of significant economic growth from the mid 1870s to the mid 1890s, and even in many countries during the booming 1920s. One may also find several examples of prices rising rapidly, despite output downturns, e.g. during the 1970s, when the combination of increasing inflation and stagnating output was named stagflation.

However, some work is done, basically on contemporary data, on the relationship between business cycles and prices. This new research indicates that there was no clear correlation between price movements and business cycles in Norway from 1970 onwards.<sup>6</sup> This can probably, at least partly, be explained by Norwegian dependency on petroleum and petroleum prices, which can act counter-cyclical to international business cycles. Petroleum prices constitute a significant cost for the Western economies. Thus, demand will shift from output produced in the Western economies over to a necessary input to the economy. In consequence, prices increase and outputs decrease. However, the same pattern of lacking correspondence between prices and business cycles during the last decades is also discovered for the US, which in nature is a quite different kind of economy.<sup>7</sup> On the other hand it is also found evidence of comovement between prices and output in the US economy since World War II.<sup>8</sup>

## 4 A small open raw material based economy

Ever since the first steps towards an international Norwegian economy, when the Hanseatic League established itself in the foremost Norwegian city, Bergen, in the 1350s, Norway's export sector relied upon raw materials. Fisheries and forestry made up the two most important export industries until the nineteenth century. Thereafter, the merchant fleet showed a rapid growth in the mid-decades of the 1800s and became the predominant export industry together with fisheries and forestry.<sup>9</sup> The growth of the Norwegian merchant fleet was heavily dependent on worldwide transport of raw materials.

Since the 1970s the petroleum industry has become the predominant Norwegian export industry. However, still fish and fish products and wooden

---

<sup>5</sup>Kondratiev 1926, 573–609, Schumpeter 1939, 87–139.

<sup>6</sup>Husebø and Wilhelmsen 2005, 1–23.

<sup>7</sup>Stock and Watson 1998, King and Rebelo 2000.

<sup>8</sup>Haan 2000, 3–30.

<sup>9</sup>Brautaset 2002, 197–205.

based products, like pulp and paper are important Norwegian export products. Due to its dependence on foreign markets both regarding exports and imports, Norway has in the large with a few exceptions been in favor of free international trade.<sup>10</sup> Thus, one can definitely claim that Norway always has been a small, open, raw material based economy. This would apply that the Norwegian business cycle should very much depend on the business cycles within our most important trading partners. Huge demand of raw materials should normally give both high prices and a boom in the economic activity.

On the other side the abundance of raw materials would be decisive for the level of supply and thereby both the price levels and economic activity in the economy. E.g. small fish catches would normally cause fish prices to increase, when output volumes decrease. In such a case the business cycle is caused by a supply side shock, and prices and output should be negatively correlated.

It is a complicated task to decide whether business cycles are demand or supply led. In this paper we focus on the statistical correlation between prices and business cycles. On the basis of these results, we can draw some conclusions on the likeliness of the business cycles to have been demand side led in the small open raw material dependent economy of Norway 1830–2006. Further, in order to conclude on the possible correspondence between short-term output and price movements in Norway 1830–2006 one should look at different sub-periods of time. This paper deals with three such sub-periods.

**1830–1913** The first sub-period stretches from 1830 till 1913, and represents the pioneer period of modern economic growth within a liberal economic order in Norway.<sup>11</sup> For most of this period the monetary system was fairly stable with a real silver standard 1842-1873 and a real gold standard 1874-1913. During the first years of the sub-period, i.e. 1830-1842 the central bank monitored a nominal silver standard, with a careful deflationary monetary policy in order to obtain the par silver value of the *speciedaler*.

**1913–1952** The second sub-period starts in 1913 and ends in 1952. This was a very volatile period for both the international and the domestic economy, characterized by two world wars and their corresponding post-war periods, crises and growth, and inflation and deflation.<sup>12</sup> During this period several years can be characterized as turbulent regarding the monetary situation.

**1952–2006** Our final sub-period covers the years 1952-2006 and is characterized by a significant and growing public sector and a social-democratic

---

<sup>10</sup>Hanisch 1999, 17–20.

<sup>11</sup>Hodne and Grytten 2000, 59–276.

<sup>12</sup>Hanisch 1996, 141–156.



economic planning regime. Domestically these features were inspired by John Maynard Keynes and Ragnar Frisch.<sup>13</sup> Admittedly, Norway gradually returned to a more neo-liberalistic economic world order since 1979. Nevertheless, economic planning in a mixed economy is still a dominant economic regime. The monetary policy was fairly stable with the exception of some turbulence in particular in the 1970s and 1980s.

## 5 Data

As indicator for the general price level we use a newly published combined cost of living index (CLI) and consumer price index (CPI) for Norway, hereafter denoted as a historical CPI.<sup>14</sup> As for business cycles, we use newly published historical gross domestic product (GDP) figures, reflecting total output in the economy.<sup>15</sup> The available data sets allow us to compare annual figures for all years 1830 till 2006.

### 5.1 Prices

The combined historical CLI-CPI stretching back to 1516 is constructed by a traditional Laspeyres approach, which is common for historical price indices.<sup>16</sup> In fact it is a mixture of a cost of living index and a consumer price index till 1959, meaning it does not only reflect market prices, but also the costs of providing necessities for working class families. From 1959 onwards, it stands as a pure consumer price index.

The series for the period in question in this paper is in fact spliced together of six different indices. The first, constructed by Ola H Grytten, covers the period 1819-1871 and it includes 29 commodities within eight consumption groups 1819-1830 and 47 commodities within nine consumption groups 1830-1871, and includes most kinds of consumption less services. Almost all observations are monthly or quarterly retail or market place prices reported all over the country by governmental decree.<sup>17</sup> The key source for these data is the Professor Dr. Ingvar B. Wedervang's Archive on Historical wages and Prices, kept at the Norwegian School of Economics and Business Administration in Bergen, Norway.

The second and third 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 till 1901, was constructed by Jan Ramstad. It was made up of price data on 55 representative commodities, recorded in the

---

<sup>13</sup>Søilen 1998, 417–446.

<sup>14</sup>Grytten 2004a, 47–98.

<sup>15</sup>Grytten 2004b, 241–288.

<sup>16</sup>Grytten 2004a, 47–98.

<sup>17</sup>Sircular, 4th Royal Norwegian Ministry, January 20th 1816 and Wedervang Archive, file 272.

Wedervang Archive.<sup>18</sup> Thereafter, we use the cost of living index from the Statistical Office of Kristiania (Oslo) for the period 1901-1916, including about 70 items.<sup>19</sup> Again all major consumption groups are included in these monthly figures, except for services, which are lacking till 1900, and thereafter are underrepresented.

The fourth index series was constructed by the Ministry of Social Affairs during a short period stretching from 1916 till 1919. It covers 16 of the major urban areas of Norway at the time and includes 60 retail commodities, fuel inclusive. The observations were taken on a monthly basis.<sup>20</sup>

From 1919 Statistics Norway took over as the major provider of cost of living indices. They conducted several consumption surveys, covering up to 31 urban areas and collected retail price data on some hundred consumption items, i.e. from 120 in 1920 to 700 in 1959. Data were compiled all over the country in order to construct this index. Finally, in 1959/1960 the cost of living index for working class households was fully replaced by a consumer price index (CPI) representing all kinds of households and products, which can be bought in retail shops at market prices. The range of data compilation has been increased gradually. Today Statistics Norway collects retail prices of a set of about 1000 representative commodities from all over the country.<sup>21</sup> During the last years they have monitored a CPI constructed as a geometrical series. However, in our historical series we still use an arithmetic approach.

## 5.2 GDP

In order to map the business cycles we use gross domestic product per capita in fixed prices, which expresses the total volumes of output or value added in the economy. The historical national accounts for Norway stretch back to 1830, and are calculated in several steps.

In 1965 Statistics Norway published GDP per capita for the years 1865-1960.<sup>22</sup> These have newly been revised back to 1970.<sup>23</sup> Thereafter, new calculations were made of GDP back to 1830 by a group of scholars from the Norwegian School of Economics and Business Administration in Bergen.<sup>24</sup> Again, an important source, both of volumes and prices, is the Wedervang Archive. The calculations are made both from the production and the expenditure side, and to reach at estimates in fixed prices we have in principle used a double deflation technique. Thirdly, we use the newly revised contemporary GDP-figures for 1970-2006 calculated and maintained by Statistics

---

<sup>18</sup>Ramstad 1982, 471–493.

<sup>19</sup>NOS 1978, 518–519.

<sup>20</sup>NOS 1994, 289–292.

<sup>21</sup>NOS 1994, 289–292.

<sup>22</sup>NOS 1965, 64–371.

<sup>23</sup>[www.ssb.no/emner/09/01/nr/index.html](http://www.ssb.no/emner/09/01/nr/index.html)

<sup>24</sup>Grytten 2004b, 272–289.

Norway.

Finally, the historical GDP-calculations for 1830-1865, 1865-1950 and the revised contemporary figures 1970-2006 are spliced together. These series were first published by the central bank of Norway as part of a project on historical monetary statistics.<sup>25</sup> Together with the price data they constitute valid and reliable sources for examination of the correspondence between price movements and business cycles in Norway 1830-2006.

### 5.3 Statistical properties: unit root and cointegration

Before we carry out any statistical analysis of the relationship, we investigate the time series properties. Figure 1 shows  $\ln$  CPI (henceforth CPI) and Figure 2 shows  $\ln$  real GDP per capita (henceforth GDP) 1830–2006. By a visual inspection of the two series (top panel in the Figures), it seems that the series are not stationary. This is highly common for macroeconomic time series. 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.

To formally test for a unit root we employ the Augmented Dicky-Fuller (ADF) test.<sup>26</sup> The number of lags is chosen as the highest significant lag out of a maximum of five lags. The test statistics for the CPI and GDP are reported in Table 1. From the table it is clear that neither the CPI nor the GDP series is stationary regardless of whether we include only a constant or a constant and a trend component. In all cases the test statistic is larger than the critical values.

The lower panel of Figures 1 and 2 shows the first difference series of the CPI and GDP. Both series seems to fluctuate around zero with no drift or trend. Hence, we suspect that both the first difference series are stationary. This is formally confirmed by the ADF test. The results are reported in the lower part of Table 1 where the letter D denote the difference operator. Both the differenced CPI and GDP are stationary at the 1% significance level. Hence, we conclude that both series are integrated of order one, i.e.,  $CPI \sim I(1)$  and  $GDP \sim I(1)$ .

A weakness with the ADF test is that it does not allow for any structural break in the series. To allow for this we apply the Zivot and Andrews

---

<sup>25</sup>Eitrheim 2004, Eitrheim 2007.

<sup>26</sup>Most estimations in 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*.

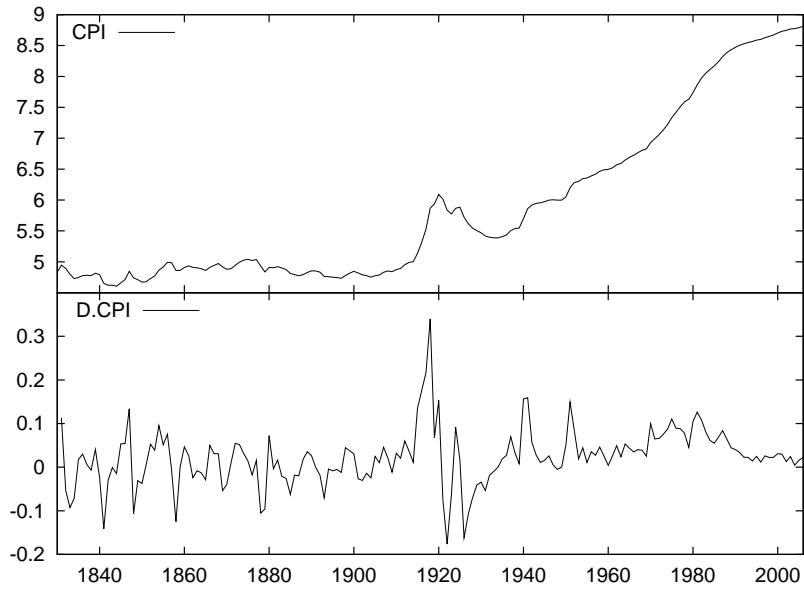


Figure 1:  $\ln$  CPI in levels and first difference.

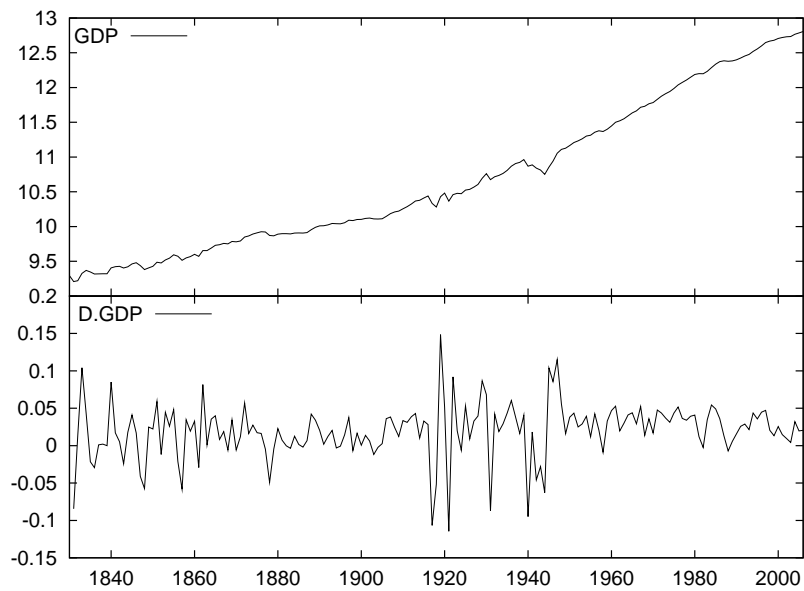


Figure 2:  $\ln$  real GDP per capita in levels and first difference.

Table 1: Unit root tests CPI and GDP for Norway 1830–2006.

Variable	ADF	Critical values			Asymptotic $p$ -value
		1%	5%	10%	
CPI (c)	1.4153 (1)	-3.485	-2.885	-2.575	0.9991
GDP (c)	2.7388 (5)	-3.486	-2.885	-2.575	1.0000
CPI (c/t)	-1.66658 (1)	-4.015	-3.440	-3.140	0.7661
GDP (c/t)	-1.09154 (5)	-4.016	-3.441	-3.141	0.9291
D.CPI	-6.75531 (0)	-2.590	-1.950	-1.615	0.0000
D.GDP	-3.96998 (3)	-2.590	-1.950	-1.615	0.0000

*Notes:* ADF = Augmented Dicky-Fuller test. Number of lags in parenthesis is chosen as the highest significant lag out of a maximum of 5 lags. c = constant and c/t = constant and trend included. In first differences there are no constant and no trend included.

test procedure<sup>27</sup> as implemented in the `zandrews` command for Stata by Christopher F. Baum.<sup>28</sup> The Zivot and Andrews test allow 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 give the same conclusion as the ADF.

Since both the CPI and GDP series are integrated of order 1,  $I(1)$ , it is natural to see if there existst any long term equilibrium relationship between the two series. Or is there only a spurious relationship? To answer this we look at whether the two time series are cointegrated, i.e., if the series share a common stochastic trend. To formally test for this we apply the Engle-Granger Augmented Dickey-Fuller test for cointegration, the EG-ADF test. Table 3 shows the test results. Using a model with only a constant the test stastic is larger than the critical values. Hence, the series are not cointegrated, i.e., the residuals from the linear combination of the CPI and the GDP is nonstationary. Using a model including both a constant and a trend the EG-ADF test concludes that the series are cointegrated. The test statistic is smaller than the critical value for the 1% significance level ( $p$ -value=0.009).

We also perform the unit root and cointegration test for the sub-periods. The results are reported in Table 4. In the first sub-period, 1830–1913, the CPI is stationary in both models, i.e., the model with a constant and the model with a constant and a trend. The GDP series is not stationary. But, since the CPI is stationary we do not test for cointegration. For the sub-period 1913–1952 the CPI and GDP are not stationary and not cointegrated.

<sup>27</sup>Zivot and Andrews, 1992.

<sup>28</sup>For a description of the `zandrews`, see e.g. Baum 2001, 9–10.

Table 2: Zivot and Andrews unit root test for CPI and GDP for Norway 1830–2006.

Variable	Break	$t$ -statistic	Break year	Critical values	
				1%	5%
CPI	intercept	-3.168 (1)	1970	-5.43	-4.80
GDP	intercept	-3.159 (2)	1945	-5.43	-4.80
CPI	trend	-3.537 (1)	1932	-4.93	-4.42
GDP	trend	-4.173 (2)	1922	-4.93	-4.42
CPI	both	-3.734 (1)	1926	-5.57	-5.08
GDP	both	-4.325 (2)	1917	-5.57	-5.08

*Notes:* Number of lags in parenthesis is chosen as the highest significant lag out of a maximum of 5 lags.

Table 3: Cointegration test between CPI and GDP for Norway 1830–2006.

Type	test statistic	Critical values			Asymptotic $p$ -value
		1%	5%	10%	
Constant	-2.38499 (3)	-3.90	-3.34	-3.04	0.3317
Constant and trend	-4.36493 (3)	-4.32	-3.78	-3.50	0.008801

*Notes:* Number of lags in parenthesis is chosen as the highest significant lag out of a maximum of 5 lags. Critical values taken from Davidson and MacKinnon 1993, 722.

For the last sub-period, 1952–2006, the time series are not stationary and not cointegrated in a model with only a constant, while in a model with a constant and a trend the CPI is stationary and we do not test for cointegration.

To summarize the statistical properties, there is evidence that both the CPI and GDP series are not stationary in levels and stationary in first differences. Although there is evidence of cointegrated CPI and GDP for the whole sample period 1830–2006, this is not the case when breaking the sample into three sub-periods. In the rest of the paper we correct for the nonstationarity in the time series with the help of a Hodrick-Prescott (HP) filter.

The HP-filter is an algorithm for finding smoothed values, i.e., trends of a time series. The filter separates an observed time series,  $\{y_t\}_{t=1}^T$ , into a smoothed or a trend component,  $g_t$ , and a cyclical component,  $c_t$ . That is,

$$y_t = g_t + c_t. \quad (6)$$

In the filtering (detrending) of  $y_t$ , the trend component  $g_t$  is determined by

$$\min \sum_{t=1}^T (y_t - g_t)^2 + \lambda \sum_{t=2}^{T-1} [(g_{t+1} - g_t) - (g_t - g_{t-1})]^2. \quad (7)$$

Here  $T$  is the sample size and  $\lambda$  is the smoothing parameter, specifying the smoothness of the trend. A normal value for  $\lambda$  is 100 for annual data. Thus, we apply  $\lambda = 100$  in our analysis.

## 6 Correspondence of annual fluctuations

In order to carry out the present historical analysis, 1830-2006, we look at the correspondence between movements in prices and GDP down to an annual basis.

Annual changes in GDP are not measurements of business cycles, due to their different time span. A business cycle is always of some time, which is more than one year, more often six to nine years. We will first examine the correspondence of annual changes.

The new data for the GDP and CPI series enable us to look at the correspondence between annual changes in output volumes prices, as plotted in Figure 3. It is surprisingly difficult to spot any significant persistent correlation between the two, in particular not a positive relationship. Thus, we cannot trace any clear tendency by just looking at these graphs.

A problem with the series used in Figure 3 is that they may be influenced by polynomial trends within the time data sets. Another problem is persistence of the data through autocorrelation of the series. This is particularly the case after World War II, when both prices and GDP increased persistently. In order to arrive at more stationary numbers we need to adjust for

Table 4: Cointegration test between CPI and GDP for sub-periods for Norway 1830–2006.

Type	test statistic	Critical values			Asymptotic $p$ -value
		1%	5%	10%	
Sub-period 1830–1913					
Unit root CPI (c)	-2.95537 (1)	-3.535	-2.904	-2.587	0.03928
Unit root GDP (c)	0.723166 (3)	-3.538	-2.906	-2.588	0.9927
Unit root CPI (c/t)	-3.22632 (1)	-4.080	-3.468	-3.161	0.07922
Unit root GDP (c/t)	-2.17283 (3)	-4.084	-3.470	-3.162	0.5043
Sub-period 1913–1952					
Unit root CPI (c)	-1.97258 (1)	-3.648	-2.958	-2.612	0.2992
Unit root GDP (c)	-0.0393117 (0)	-3.648	-2.958	-2.612	0.9491
Cointegration	-2.82403 (3)	-3.90	-3.34	-3.04	0.1582
Unit root CPI (c/t)	-2.41571 (1)	-4.242	-3.540	-3.204	0.3712
Unit root GDP (c/t)	-2.8967 (3)	-4.242	-3.540	-3.204	0.1634
Cointegration	-2.09457 (4)	-4.32	-3.78	-3.50	0.7302
Sub-period 1952–2006					
Unit root CPI (c)	-0.853369 (5)	-3.573	-2.926	-2.598	0.8032
Unit root GDP (c)	-1.19575 (1)	-3.573	-2.926	-2.598	0.6787
Cointegration	-1.81143 (4)	-3.90	-3.34	-3.04	0.6747
Unit root CPI (c/t)	-3.26942 (5)	-4.139	-3.495	-3.177	0.07136
Unit root GDP (c/t)	-1.1178 (1)	-4.139	-3.495	-3.177	0.9247

*Notes:* Critical values for the cointegration test taken from Davidson and MacKinnon 1993, 722. Number of lags in parenthesis is chosen as the highest significant lag out of a maximum of 5 lags. c = constant and c/t = constant and trend included.



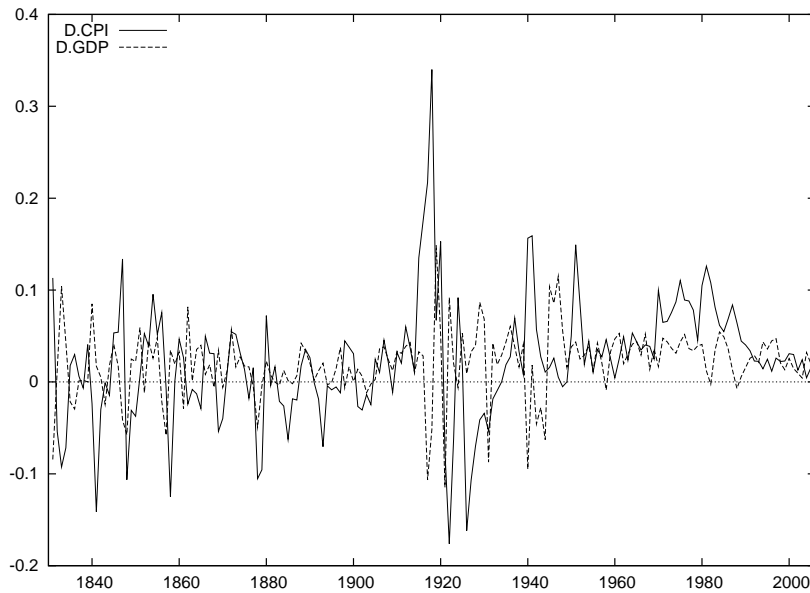


Figure 3: Annual fluctuations in CPI and GDP-volume per capita for Norway 1830-2006.

these biases of the data, and we do this, as explained earlier, by applying the HP-filter.

In Figure 4 we plot the estimated cycles of the time series. These series indicate cyclical movements within trend series made stationary. Hence, they reflect annual output gaps and price gaps quite well. Still it is very difficult to trace any consistent pattern of correlation between the two variables GDP and the historical CPI. This could be explained by time lags or by the fact that business cycles last for several years. Thus, there is not necessarily strong annual correlation between the two variables, but there may nevertheless be correlation within the typical cycle periods.

## 7 Correspondence of business cycles

It can be a too narrow approach to just look at annual changes in GDP and prices. With the exception of seasonal variations, fluctuations in output activity do not follow the calendar. One may experience that the direction of output volume turns during the year, and movements normally last for more than one year. Thus, there can be lags and leads between the two sets of variables.

This section of the paper takes account for this and focus on the correspondence between business cycles and prices. According to the business

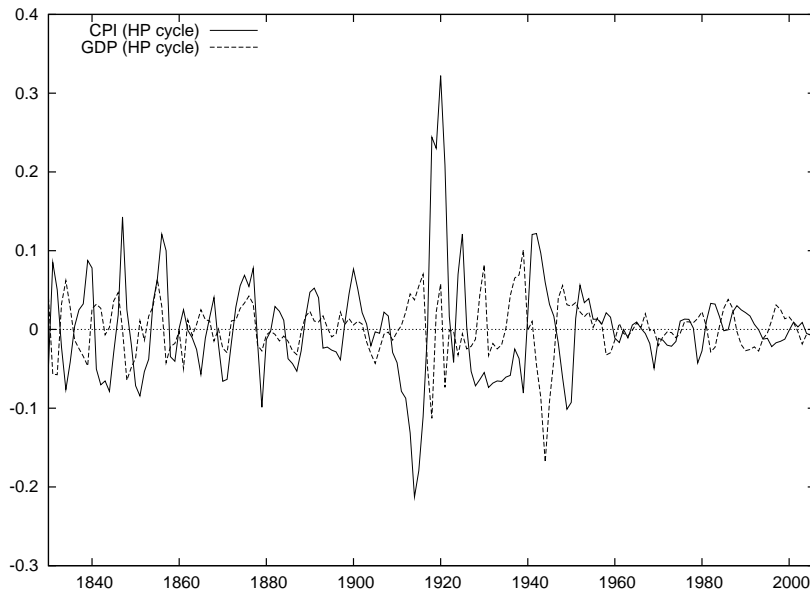


Figure 4: CPI and GDP cycles from trend estimated by HP-filter.

cycle theory pioneer Joseph Kitchin the economy moves in inventory cycles of three to five years.<sup>29</sup> According to another pioneer in the field, Clement Juglar, investment cycles of seven to eleven years are quite common.<sup>30</sup> These seem basically to be demand driven. Business cycles have tended to become shorter during the modernization of the economy. In connection with the work presented in this paper we have examined cycles of different time spans, i.e. five, seven, nine and eleven years. These different lengths do not change our conclusions, as they give very similar results. Hence, we have basically chosen a seven year business cycle approach here, which arguably can be seen as a “normal” time for a business cycle, making up the average time of Kitchin and Juglar cycles. To adjust for auto correlation and make the series more stationary we apply the HP-filter and look at the cyclical component of the time series as seven-year moving averages. This is probably the most relevant measure we offer of business cycles fluctuations around an estimated stationary trend and the corresponding price cycles in this paper.

The series are presented in Figure 5. By just looking at the graphs we can still not conclude with any different conclusions than from that drawn above. It is indeed very difficult to spot any clear and systematic short-term correlation between business cycles and price movements in Norway 1830–2006. Also, if there is any correspondence it seems more often to be

---

<sup>29</sup>Kitchin 1923.

<sup>30</sup>Juglar 1916.

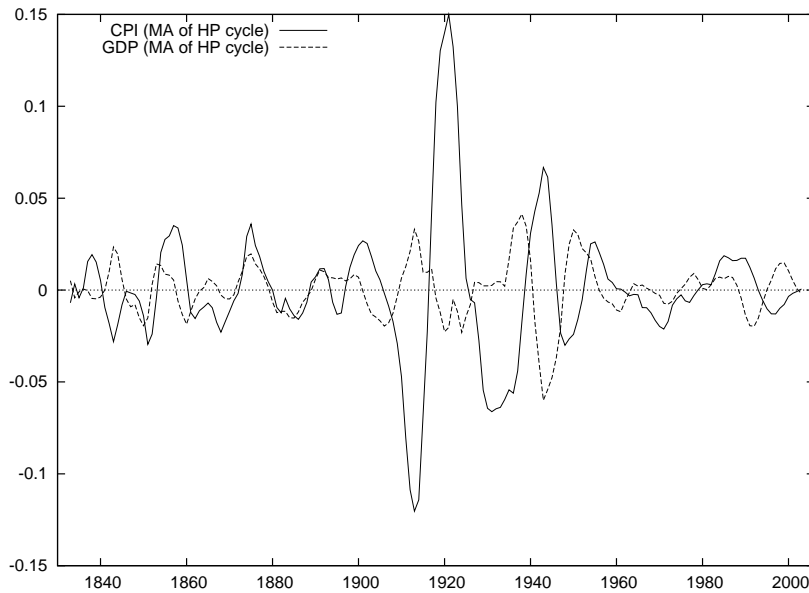


Figure 5: 7-year symmetric moving averages (MA) of HP cycles.

negative than positive. Admittedly, there seem to be some kind of a procyclical pattern between the two parameters for some periods, in particular for the years from the late 1860s to the 1890s. For the rest of the period the negative pattern seems to be stronger than the positive.

## 8 Statistical testing: correlations

In this section we compute the cross correlations between the cyclical components of the GDP and the CPI in order to look at the strength and direction of their (linear) relationship. That is, whether, the CPI is procyclical or countercyclical. We do this for both the annual cyclical component and the business cyclical component, i.e., the moving average. Although we have looked at different sets of moving averages (five, seven, nine and eleven years) we only present the seven-year symmetric moving averages since the differences between them are insignificant. In addition we compute the correlation between the two when we allow that the CPI is a leading or lagging variable of the GDP by one and two time periods. The calculations are done for all sub-periods plus for the entire time series.

According to the results presented in Table 5 most of the estimated correlations (30 out of 40) are negative. There is a significant contemporaneous negative correlation. In other words, CPI tends to be countercyclical. We also see that there is a significant strong negative correlation between current

Table 5: Correlation coefficients between GDP and CPI leads (-) and lags for Norway 1830–2006.

Lag	1830–1913	1913–1952	1952–2006	1830–2006
Annual HP cycles				
-2	0.3114***	-0.1240	0.1823	-0.0050
-1	0.3276***	-0.2502	-0.0632	-0.1105
0	0.0515	-0.3507**	-0.3270**	-0.2709***
1	-0.0560	-0.3120**	-0.3019**	-0.2810***
2	-0.0813	-0.2415	-0.0621	-0.2372***
Business cycles defined as 7-year MA of HP cycles				
-2	0.5193***	-0.1353	0.1825	-0.0499
-1	0.5149***	-0.3257*	0.0411	-0.2358***
0	0.3431***	-0.5020***	-0.1182	-0.4044***
1	0.1225	-0.6129***	-0.2546*	-0.5205***
2	-0.0464	-0.6275***	-0.3432**	-0.5594***

\*, \*\*, and \*\*\* denotes significance at 10%, 5%, and 1% significance level.

GDP and lagged values of the CPI. But, there is no significant correlation between the cyclical components of GDP and leading CPI. This comes as no surprise since prices are more likely to reflect than decide fluctuations in output. Hence, the results with simultaneous data or price-lags are more relevant in this analysis.

## 8.1 Sub-periods

During the first sub-period 1830–1913, we in fact have none significant negative coefficients. The correlations with one and two year price leads are significantly positive on the annual data and even more so for the seven-year moving averages. Thus, our calculations for 1830-1913 indicate positive correlations between prices and output both on an annual and a business cycle level, where prices moves ahead of output. This positive relationship on the aggregated national level is found despite a clear negative relationship between output and prices from agriculture, as shown in Figure 6.<sup>31</sup> The negative correlation coefficient ( $-0.4034$ ) for agriculture, clearly indicates that supply side shocks were decisive for the annual development of output and prices in this important industry, when the opposite seems to have been the case for the economy in general.

For the second sub-period, 1913–1952, we find negative correlations only.

<sup>31</sup>Grytten 2004c, 47–76 and Grytten 2004a, 47–98.

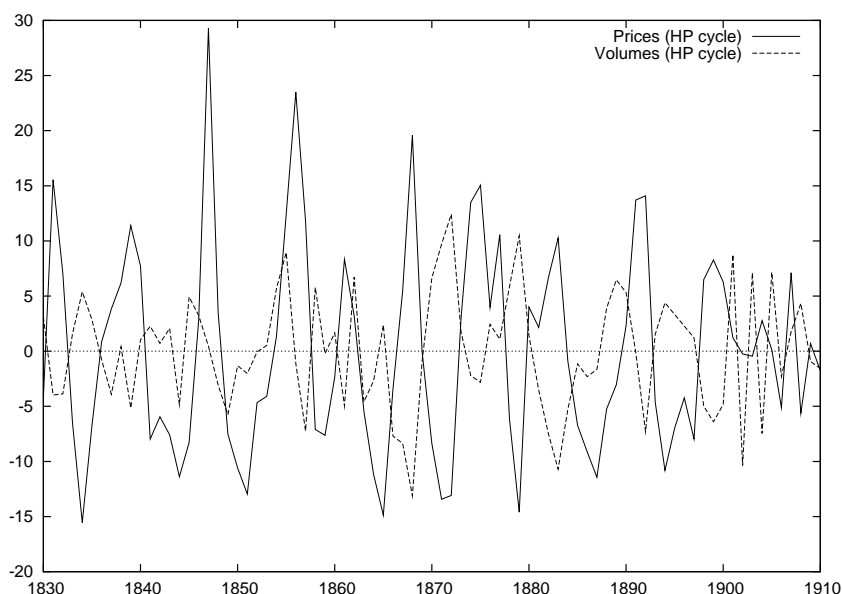


Figure 6: HP cycle for prices and volumes in agriculture in Norway 1830–1910. ( $\lambda = 100$ ).

Six out of ten are significant at least at a ten per cent level. The estimated coefficients are also relatively high. Again, they are highest for business cycles versus prices contra annual output versus prices.

This was a period of several shocks to the economy.<sup>32</sup> In the first place two world wars took place during these years. Inflation grew rapidly during the war years, when output contracted. Secondly, two huge international depressions hit the economy devastatingly. Thirdly, Norway ran a strong deflationary monetary policy for most of the 1920s, causing a sharp and long period of deflation in the 1920s in addition to the international deflation in the 1930s. Fourthly, during the post World War II period till 1952, the government widely subsidized and directed the economy in order to prevent high inflation and thereafter a postwar depression.<sup>33</sup> Between these years of crises and abnormal economic policy, a significant growth took place. From 1913 till 1952 the recorded per capita GDP growth rate was impressively 2.24 per cent.<sup>34</sup>

This implies that the years 1913-1952 constitute a period of substantial economic growth both when compared to Norwegian historical growth rates and growth rates of other countries during the same period. However, due

<sup>32</sup>Klovland 1998, 309–344.

<sup>33</sup>Hodne and Grytten 2002, 77–196.

<sup>34</sup>NOS 1965, 348–351.

to the two great wars, their aftermaths and the long period of deflationary monetary policy, one can easily see that the economy in many years must have been influenced by heavy supply side shocks and that prices could not necessarily have mirrored the business cycles.

For the third sub-period, 1952–2006, we basically find negative correlations. They are still negative when we apply one and two year price lags to output, and they are significant except for two year price lag when looking at annual changes. Price leads are for most part positive, but they are not significant. Despite the dominant Keynesian paradigm in this period, we chiefly find negative relationships between prices and output.<sup>35</sup>

There was not any significant primary sector to impose huge supply side shocks to the Norwegian economy after 1952. Still prices and business cycles were negatively correlated. This could partly be explained by the adoption of technology from the US, causing productivity and prices to increase and the economy to boom. During the 1970s, the economies of the OECD-countries were heavily influenced by the considerable jumps of petroleum prices caused by OPEC I, in 1973 (petroleum embargo), and OPEC II, in 1979 (Iraqi-Iranian war). Oil prices per barrel stepped up from three to 40 dollars during the 1970s. In consequence, the OECD-area experienced high inflation and fall in demand for domestically produced goods. Thus, changes in prices and output moved in opposite directions.

As for the entire period, 1830–2006, our calculations give negative correlations. Seven out of ten are significant at a one per cent level. Also, the calculations reveal that the negative correlations are stronger for business cycles than for annual movements and that the correlations are stronger for computations done with price-lags than for those done with price leads.

All in all, on the basis of the computations reported in Table 5 we can conclude that for the historical period 1830–2006 it is more common with negative correspondence between prices and output than positive. The exception for this phenomenon is the sub-period 1830–1913, when the tendency is pro-cyclical. The strongest counter-cyclical period exists for the very turbulent years 1913–1952.

## 9 The foreign sector

In order to get a better understanding of the observed phenomena in the small open raw material based economy of Norway it is of interest to see if the development has been influenced by the foreign sector. Thus, in this section of the paper we take a closer look at the correspondence between export and import prices versus output from the economy. The export and import prices used are taken from the historical national accounts. We use the implicit price indices. Sources for the export and import price series

---

<sup>35</sup>Hanisch 1999, 17–28.

in the historical national accounts are public records and the Wedervang Archive.<sup>36</sup>

An important aspect of this examination is to find out how external shocks have influenced Norwegian output through import or export prices. Additionally, this examination can inform us on how other supply side shocks, e.g. low or high fish catches, output from forestry or oil and gas relative to demand has influenced the relationship between prices and output.

We conduct this examination with further calculations of correlation coefficients. When simultaneous and price-lagged series are the most relevant when examining a possible Keynesian relationship between output and prices, simultaneous and price-led series would be the most relevant in this analysis. The idea is to examine if external supply side shocks can explain fluctuations in output.

## 9.1 Exports

First we present correlation calculations for export prices versus GDP per capita in Table 6. The estimates are done on series made stationary with the help of the HP-filter, and we look at the cyclical components. Our output data are taken from the historical GDP-series for Norway, where the price series is the implicit deflator for exports.<sup>37</sup>

According to estimates reported in Table 6 there was a positive correlation between export prices and output, both for annual movements and business cycles, 1830-1913. The correlation is significant at 10% level when we look at both simultaneous and one-year price lead and lag annual series. They are also significant at a 1% level when we look at output and price leads in the corresponding business cycle series. In the same series, output and one price lag is significant at 10% significance level. This indicates that positive shifts in export prices were mirrored in positive shifts in output during this sub-period. Thus, the export sector of the supply side contributes to explain the positive co-movements of output and prices in this period. This is fairly understandable for a small open raw material based economy.

As for the turbulent sub-period 1913-1952 we find negative correlations only. Six out of ten of these are significant at a 10% or lower significance level. The estimates carried out on the basis of price lag calculations give the strongest results. Additionally, the correlation is stronger for business cycles than for annual movements. These results are in line with those reported in Table 5, suggesting considerable negative counter-cyclical movements for general prices versus output 1913-1952. Also for the third sub-period we find negative correlations when looking at annual changes and positive correlations when looking at the business cycle. However, these correlations

---

<sup>36</sup>Wedervang Archive, files W272, W276 and W383.

<sup>37</sup>Grytten 2004b, 281–283.

Table 6: Correlation coefficients between GDP and implicit price deflator leads (-) and lags for Norwegian exports 1830–2006.

Lag	1830–1913	1913–1952	1952–2006	1830–2006
Annual HP cycles				
-2	0.0935	-0.1469	-0.0342	-0.0392
-1	0.2056*	-0.1372	-0.1596	-0.0615
0	0.1819*	-0.2044	-0.1242	-0.1292*
1	0.1821*	-0.3594**	-0.0998	-0.2384***
2	0.0733	-0.2771*	-0.0848	-0.2176***
Business cycles defined as 7-year MA of HP cycles				
-2	0.4548***	-0.1822	0.2806**	0.0644
-1	0.4445***	-0.3195*	0.1735	-0.0847
0	0.3572***	-0.4406**	0.1157	-0.2230***
1	0.2106*	-0.5317***	0.0736	-0.3414***
2	0.0189	-0.5496***	0.0162	-0.4116***

\*, \*\*, and \*\*\* denotes significance at 10%, 5%, and 1% significance level.

are statistically insignificant except for the coefficient between output at two year price lead for the business cycle.

For the entire time span, 1830–2006, we find negative correlations only except for the coefficient between output at two year price lead for the business cycle. All the coefficients for contemporaneous and lag cross correlations are significant at 10% or lower significance level. The correlations between output and price leads are not significant. Hence, looking at the period as a whole there is a clear negative co-movement between export prices and output from the economy. This is very much in line with the pattern for the total economy. And again, the evidence is strongest for the business cycles, and stronger for the price lag series than the simultaneous series. Thus, supply side shocks from the export industries seem to have had an effect on the economy. Supply side shifts from the export sector which have made production costs fall have caused input volumes increase.

## 9.2 Imports

The estimated co-movements of import prices and output are reported in Table 7. Again, we find significantly positive correlations for the first sub-period. The significance pattern is exactly as for the export prices (cfr. Table 6). The positive correlations indicate that negative supply side shifts from the import side had a negative effect on output. This can in a broader



Table 7: Correlation coefficients between GDP and implicit price deflator leads (-) and lags for Norwegian imports 1830–2006.

Lag	1830–1913	1913–1952	1952–2006	1830–2006
Annual HP cycles				
-2	0.1023	-0.0558	0.1008	0.0083
-1	0.2686**	-0.1168	-0.0381	-0.0266
0	0.4144***	-0.4623***	-0.0731	-0.2280***
1	0.3267***	-0.5591***	-0.1095	-0.3234***
2	0.0346	-0.3303**	-0.0668	-0.2553***
Business cycles defined as 7-year MA of HP cycles				
-2	0.3504***	-0.2069	0.1662	-0.0259
-1	0.4083***	-0.4217**	0.1339	-0.2044***
0	0.3880***	-0.6183***	0.1119	-0.3708***
1	0.2375**	-0.7124***	0.0752	-0.4880***
2	0.0085	-0.6681***	0.0152	-0.5237***

\*, \*\*, and \*\*\* denotes significance at 10%, 5%, and 1% significance level.

perspective be explained by international price movements, i.e. when international prices fell Norwegian output fell. In this way Norwegian output in the nineteenth century may mirror the international business cycles.<sup>38</sup> This again confirms our findings that prices and output basically moved in the same direction 1830-1913.

For the next period, 1913–1952, we find significant negative correlations for all but three correlations (price leads). The tendency is strongest on the one-year price lag series, and stronger for business cycles than annual movements. This indicates that negative price shocks on imported goods gave fuel to domestic output.

As for the years 1952–2006 we again observe negative co-movements for all estimates except one when looking at annual changes, and positive co-movements for the business cycle. However, none of these are significant. Thus the relationship between import prices and output from the Norwegian economy in this period is unclear.

Finally, looking at the full time span 1830–2006, we find mostly negative correlations, and most of them are significant at a 1% significance level. Thus, the common pattern is that import prices and output from the Norwegian economy move in different directions. The lagged cross-correlations are stronger than the contemporaneous correlations. The correlations are

<sup>38</sup>Hodne 1983, 262–269.

also stronger for business cycles than for annual developments. Arguable, external supply side shocks seem to have influenced the economic output.

To sum up, both export and import prices indicate that supply side shocks are decisive in order to explain the counter-cyclical movements between prices and output in Norway from World War I until present. During the years prior to the war, i.e. 1830-1913, we do not find this counter-cyclical tendency and the effect on external supply shocks on short term output is not clear for this period.

## 10 Robustness

In the main analysis of the paper we apply the HP-filter which is one of the most used filter methods in empirical work. However, in recent years band pass (BP) filters have become common.<sup>39</sup> One of the main differences between the band pass filters and the HP-filter is that the band pass filters “are combinations of MA filters designed to eliminate both high and low frequency movements in the data. [...] Furthermore, BP are appealing because they make the notion of business cycle operational by selecting fluctuations in the prespecified range.”<sup>40</sup> In other words, one must have *a priori* expectations of how long a typical business cycle is and the band pass filter “passes periodic components that lie within a pre-specified frequency band and eliminates everything else.”<sup>41</sup> Common values for the limits of the business cycle in the literature is 1.5 to 8 years.

As a robustness test we estimate the correlations corresponding to Tables 5, 6 and 7 applying the Baxter-King and Christiano-Fitzgerald band pass filters.<sup>42, 43</sup> As stated earlier in the paper, we define a typical business cycle to be within the range of 2 and 7 years. The robustness tests basically verify our results. Admittedly, the negative correlations between output and prices may tend to be slightly weaker when we apply these filters. However, they do not alter our conclusions in any direction.

## 11 Conclusions

The present paper offers an empirical investigation of the short-term correspondence of historical output versus prices 1830-2006 for the small open raw material based economy of Norway. The examination is done both with an annual and a business-cycle approach. Except for the times before World War I, where there is a weak, but basically significant correlation between

---

<sup>39</sup>Canova 2007, p. 94.

<sup>40</sup>Canova 2007, p. 94

<sup>41</sup>Cogley 2008.

<sup>42</sup>Baxter and King 1999, Christiano and Fitzgerald 2003.

<sup>43</sup>See Appendix A in Haug and Dewald 2004 for a nice technical overview of the filters.

Table 8: Robustness checks for the correlation coefficients between GDP and CPI and implicit price deflator leads (-) and lags for Norwegian exports and imports 1830–2006. Cycles estimated with the Baxter-King band pass filter.

Lag	1830–1913	1913–1952	1952–2006	1830–2006
Correlation GDP and CPI				
–2	0.1463	–0.0421	0.1824	0.0062
–1	0.2845**	–0.0103	0.0293	0.0779
0	–0.0291	–0.1513	–0.4208***	–0.1175
1	–0.1570	0.0846	–0.3025**	–0.0668
2	–0.0552	0.0594	0.1029	–0.0045
Correlation GDP and implicit price deflator exports				
–2	–0.0749	–0.3511**	–0.2366*	–0.2311***
–1	0.0493	0.1260	–0.2284	0.0571
0	–0.0382	0.1971	0.1114	0.1042
1	0.1729	–0.2506	0.0932	–0.1375*
2	0.1549	–0.1230	–0.1282	–0.1182
Correlation GDP and implicit price deflator imports				
–2	0.0143	–0.0820	–0.0740	–0.0425
–1	0.0027	0.4007**	–0.1253	0.2272***
0	0.2289**	–0.2450	0.0370	–0.0875
1	0.1924*	–0.3628**	–0.0289	–0.2086***
2	0.0437	0.0582	–0.0480	0.0086

\*, \*\*, and \*\*\* denotes significance at 10%, 5%, and 1% significance level.

Table 9: Robustness checks for the correlation coefficients between GDP and CPI and implicit price deflator leads (-) and lags for Norwegian exports and imports 1830–2006. Cycles estimated with the Christiano-Fitzgerald band pass filter.

Lag	1830–1913	1913–1952	1952–2006	1830–2006
Correlation GDP and CPI				
–2	0.2227**	–0.1354	0.2541*	0.0144
–1	0.3011***	0.1029	–0.0755	0.1454*
0	–0.2092*	0.0795	–0.5392***	–0.0831
1	–0.183*	0.1453	–0.3786***	–0.0150
2	0.0955	–0.0051	0.2329*	0.0684
Correlation GDP and implicit price deflator exports				
–2	–0.1101	–0.3732**	–0.1718	–0.2242***
–1	–0.0248	0.2638*	–0.1391	0.0837
0	–0.1160	0.3826**	0.1264	0.1469*
1	0.1181	–0.2123	0.1073	–0.0968
2	0.1723	–0.2768*	–0.1151	–0.1145
Correlation GDP and implicit price deflator imports				
–2	–0.0180	–0.0292	–0.0333	–0.0260
–1	0.0179	0.5772***	–0.1453	0.3031***
0	0.2049*	–0.0616	–0.0111	0.0222
1	0.1344	–0.3625**	–0.0517	–0.1686**
2	–0.0235	–0.0373	–0.0388	–0.0302

\*, \*\*, and \*\*\* denotes significance at 10%, 5%, and 1% significance level.

the two sets of variables, we find chiefly significant negative correlations. Thus, prices do not seem to reflect short-term movements in the economy. This is contrary to the typical Keynesian view, i.e. demand is decisive for the short-term economic performance. In consequence, prices should mirror short-term swings in the economy. However, they did not for Norway during most of the twentieth century until present days. On the contrary, short term prices and output more often moved in opposite directions.

On the basis of the chiefly counter-cyclical historical movements between general output and prices and similar results for export and import prices versus output, we conclude that domestic and in particular external supply side shocks offer important information in order to understand historical short-term output movements.

## References

- Abramowitz, Moses 1956, "Resource and output trends in the US since 1870", *American Economic Review*, 46, 5-23.
- Baxter, Marianne and Robert G. King 1999, "Measuring Business Cycles: Approximate Band-Pass Filters for Economic Time Series", *The Review of Economics and Statistics*, Vol. 81, no. 4, 575-593.
- Baum, Christofer F. 2001, "Stata: The language of choice for time series analysis?", *The Stata Journal*, Vol. 1, no. 1, 1-16.
- Bergh, Trond et al 1983, *Norway from an underdeveloped to an industrial economy*, Oslo: Gyldendal.
- Brautaset, Camilla 2002, *Norwegian Exports 1830-1865: in perspective of historical national accounts*, Bergen: NHH.
- Canova, Fabio 2007, *Methods for Applied Macroeconomic Research*, Princeton University Press.
- Christiano, Lawrence J. and Terry J. Fitzgerald 2003, "The Band Pass Filter", *International Economic Review*, Vol. 44, No. 2, 435-465.
- Cogley, Timothy 2008. "Data filters." *The New Palgrave Dictionary of Economics*. Second Edition. Eds. Steven N. Durlauf and Lawrence E. Blume. Palgrave Macmillan.
- Davidson, Russell and James G. MacKinnon 1993, *Estimation and Inference in Econometrics*, New York: Oxford University Press.
- Eitrheim, Øyvind et al 2004, *Historical Monetary Statistics for Norway 1819-2003*, Oslo: Norges Bank.

- Eitrheim, Øyvind et al 2007. *Historical Monetary Statistics for Norway, part 2*, Oslo: Norges Bank.
- Furre, Berge 1991, *Vårt hundreår: Norsk historie 1905–1990*, Oslo: Samlaget.
- Glynn, Sean and Alan Booth (eds), *The road to full employment, London*, Allen & Unwin.
- Grytten, Ola Honningdal 2004a, “A consumer price index for Norway 1516–2003”, Eitrheim, Øyvind et al (eds), *Historical Monetary Statistics for Norway 1819–2003*, Oslo: Norges Bank, 47–98.
- Grytten, Ola Honningdal 2004b, “The gross domestic product for Norway 1830–2003”, Eitrheim, Øyvind et al (eds), *Historical Monetary Statistics for Norway 1819–2003*, Oslo: Norges Bank, 241–288.
- Grytten, Ola Honningdal 2004c, “A Norwegian consumer price index 1819–1913 in a Scandinavian perspective”, *European Review of Economic History*, 8, 47–76.
- Haan, Wouter J den 2000, “The comovement between output and prices”, *Journal of Monetary Economics*, 46, 3–30.
- Hanisch, Tore Jørgen 1996, *Om valget av det gode samfunn*, Kristiansand: Høyskoleforlaget.
- Hanisch, Tore Jørgen et al 1999, *Norsk økonomisk politikk i det 20. århundre*, Kristiansand: Høyskoleforlaget.
- Haug, Alfred A. and William G. Dewald 2004, “Longer-Term Effects of Monetary Growth on Real and Nominal Variables, Major Industrial Countries, 1880–2001”, Working paper no. 382, European Central Bank.
- Hodne, Fritz 1983, *The Norwegian Economy 1920–1980*, London: Croom-Helm.
- Hodne, Fritz and Ola Honningdal Grytten 2000, *Norsk økonomi i det 19. århundre*, Oslo: Fagbokforlaget.
- Hodne, Fritz and Ola Honningdal Grytten 2002, *Norsk økonomi i det 20. århundre*, Oslo: Fagbokforlaget.
- Hodne; Fritz 1983, *The Norwegian Economy 1920–1980*, London: Croom-Helm.
- Husebø, Tore Anders and Bjørn-Roger Wilhelmsen 2005, “Norwegian Business Cycles 1982–2003”, *Staff Memo*, 2/2005, Economics Department, Norges Bank, 1–23.

- Juglar, Clement 1916, *A Brief History of Panics and Their Periodical Occurrence in the United States*, 3. ed, Gutenberg project.
- Keynes, John Maynard 1936, *The general theory of employment, interest and money*, Cambridge: Macmillan.
- King, R. and S.T. Rebelo 2000, “Resuscitating real business cycles”, *Working Paper*, 7534, NBER.
- Kitchin, Joseph 1923, “Cycles and trends in economic factors”, *Review of Economics and Statistics*, 5, 10-16.
- Klovland, Jan Tore, 1998, “Monetary policy and business cycles in the interwar years: the Scandinavian Experience”, *European Review of Economic History*, 2, 309-344.
- Kondratiev, Nikolai 1926, “Die langen Wellen der Konjunktur”, *Archiv für Sozialwissenschaft und Sozialpolitik*, 56: 573-609.
- NOS C. 188 1994, *Historical Statistics 1994*, Oslo: Statistics Norway.
- NOS XII. 291 1978, *Historical Statistics 1978*, Oslo: Statistics Norway.
- NOS. 163 1965, *National Accounts 1865-1960*, Oslo: Statistics Norway.
- Peden, George 1987, “Keynes”, Glynn, Sean and Alan Booth (eds), *The road to full employment*, London, Allen & Unwin, 82-96.
- Ramstad, Jan 1982, *Kvinnelønn og pengeøkonomi*, Bergen: NHH.
- Schumpeter, Joseph 1939, *Business cycles: a theoretical, historical and statistical analysis of the Capitalist process*, New York: McGraw-Hill.
- Sejersted, Francis 1973, *Historisk introduksjon til økonomien*, Oslo: Cappelen.
- Sircular, 4th Royal Norwegian Ministry, January 20th 1816.
- Søilen, Espen 1998, *From Frischianism to Keynesianism*, Bergen: NHH.
- Stock, J.H and M.W. Watson 1998, “Business cycle fluctuations in US macroeconomic time series”, *Working Paper*, 6528, NBER.
- Wedervang Archive, files W272, W276 and W383.
- [www.ssb.no/emner/09/01/nr/index.html](http://www.ssb.no/emner/09/01/nr/index.html)
- Zivot, Eric and Donald W. K. Andrews 1992, “Further evidence on the great crash, the oil-price shock, and the unit-root hypothesis”, *Journal of Business & Economic Statistics*, vol. 10, no. 3, 251–270.