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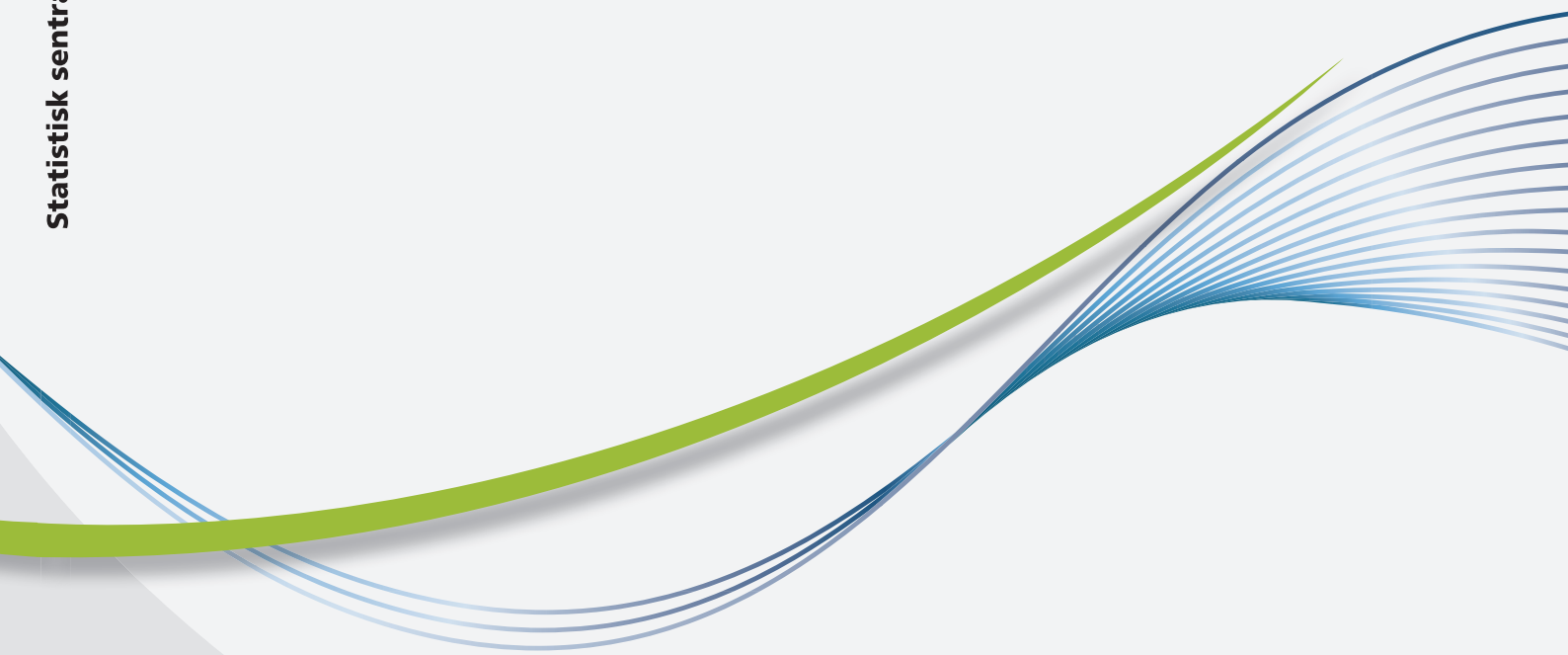
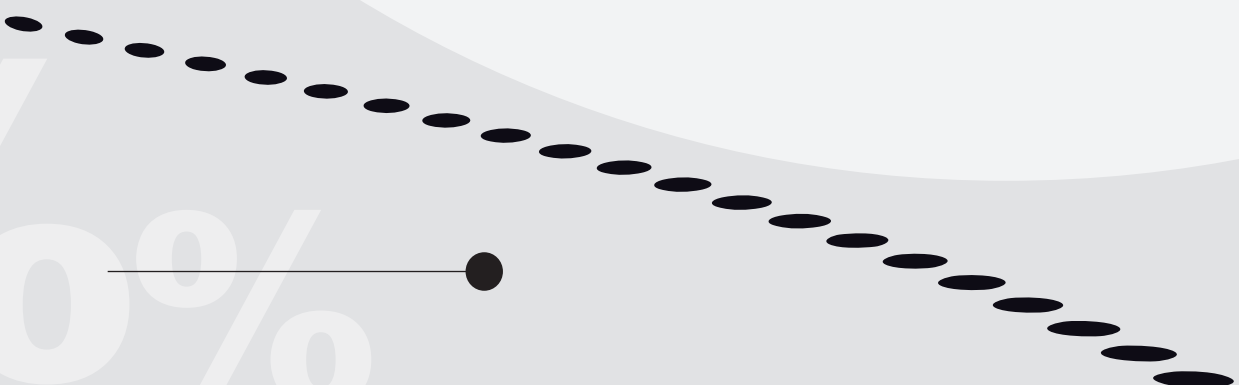
Nini Barth, Thomas Von Brasch

Decomposition of growth in real disposable income





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Category not applicable	.
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Preface

This document presents two different decompositions of growth in real disposable income. The publication was prepared by Nini Barth and Thomas von Brasch. We would like to thank Ådne Cappelen, Tore Halvorsen and Steinar Todsen for useful comments.

Statistics Norway, October 2, 2016

Anna Rømo

Abstract

In the course of the past 45 years, Norway has gone from being a moderately prosperous country to one of the wealthiest countries in the world at the end of the first decade of this century. This document refers to two different decompositions that may assist in an understanding of income developments. The first chapter provides the background to the document. The second chapter briefly reviews growth in real disposal income in Norway since 1970. The third chapter shows contributions to growth in real disposable income in Norway decomposed into contributions from production growth, terms of trade effects and changes in the balance of income and current transfers to and from abroad. In the fourth chapter, accumulated growth in real disposable income per capita since 1970 is decomposed into the following components: 1) productivity in oil and gas extraction, 2) productivity in non-petroleum industries, 3) labour reallocation gains, 4) terms of trade effects from petroleum products, 5) terms of trade effects from non-petroleum products, 6) balance of income and current transfers and 7) hours worked per capita. Both decompositions take as their starting point the definitions in the Norwegian national accounts and both have previously been published by Statistics Norway.

Contents

1. Introduction

In the course of the past 45 years, Norway has gone from being a moderately prosperous country to one of the wealthiest countries in the world at the end of the first decade of this century. In 2015, disposable income measured in constant prices was 130 per cent higher than in 1990 and 273 per cent higher than in 1970. There was a sharp fall in real disposable income in 2009, and preliminary figures indicate that in 2015 real disposable income reverted to the level in 2008. This document reviews two different decompositions that may contribute to an understanding of what led to the income growth Norway enjoyed up to 2009, what led to the fall in income that year, and what components have contributed to growth in recent years.

The document is divided into four chapters: The first chapter provides an introduction, while the second briefly reviews growth in real disposal income in Norway since 1970. The third chapter derives a decomposition of growth in real disposable income and the fourth a decomposition of real per capita disposable income.

2. Growth in Norway's real disposable income

Table 2.1 shows growth in Norway's real disposable income decomposed into contributions from production growth in oil and gas extraction, production growth in non-petroleum industries, terms of trade effects in total, the separate terms of trade effect from the developments in prices for petroleum products, and changes in balance of income and current transfers for the years 1971–2015. Average growth in real disposable income has been 3 per cent annually since 1970. Growth in production excluding oil and gas extraction has contributed to average growth in real disposable income of 2.4 per cent annually, while production developments in oil and gas extraction have contributed with an annual average growth of 0.5 per cent since 1970. Real disposable income was at approximately the same level in 2015 as in 2008. On average, production growth in non-petroleum industries and changes in balance of income and current transfers contributed positively to income growth in the 7-year period 2008–2015. Developments in petroleum production and terms of trade losses have on average contributed negatively to income growth since 2008. Table 2.1 is published as part of the national accounts[1]. The table is also used in reports from the Norwegian Technical Calculation Committee for Wage Settlements.

Figure 2.1 shows growth in real per capita disposable income, measured in terms of the purchasing power of one krone in 2015[2]. In 1970, real per capita disposable income was NOK 186 000. The level in 1998 was 1.9 times higher than the level in 1970, and equivalent to NOK 352 000. In the 25-year period from 1970 to 1995, the average income grew relatively steadily. From 1995 to 2008 the rate of growth more than doubled, and in 2008 real per capita disposable income was NOK 561 000. However, it fell sharply from 2008 to 2009, and although there has been some growth in subsequent years, real per capita disposable income in 2015 was NOK 41 000 lower than in 2008. The total increase in income from 1970 to 2015 was NOK 334 000 per capita.

[1] http://www.ssb.no/en/nasjonalregnskap-og-konjunkturer/tables/nr-tables

[2] Figures 1and 2 were published in *Økonomisk utsyn over året 2015*, [Economic trends for the year 2015], see http://www.ssb.no/nasjonalregnskap-og-konjunkturer/oa/. The figures on amounts per capita are based on the March 2016 edition of this publication.

Table 2.1 Contribution to growth in Norway's real disposable income. Per cent

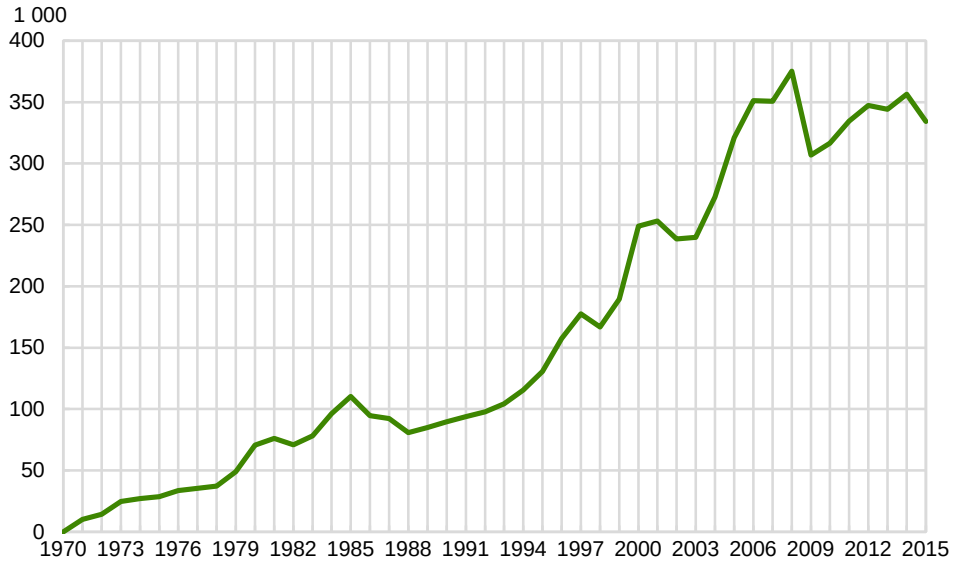
	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
Real disposable income	6.3	2.8	6.0	1.8	1.3	2.8	1.2	1.2	5.6	9.6	2.5	-1.7	3.3	7.1	5.3	-5.0	-0.4	-3.6	2.0	2.1	2.0	2.0	2.9
Contribution from growth in production in petroleum activities	0.0	0.2	-0.1	-0.3	2.2	1.2	0.0	3.0	1.4	2.5	-0.6	0.0	2.6	2.5	0.6	1.3	1.1	0.8	2.6	0.6	2.0	1.8	0.5
Other production growth	6.1	4.9	4.7	3.7	2.8	4.6	3.5	0.2	3.2	2.6	1.8	-0.7	1.5	4.2	5.4	2.6	0.3	-1.7	-2.0	1.1	1.3	2.2	2.5
Change in terms of trade	-0.1	-2.0	1.6	-1.2	-3.5	-2.3	-1.2	-1.0	2.0	4.2	1.4	-0.5	-1.3	0.2	-1.6	-9.1	-2.0	-1.5	1.7	0.7	-0.8	-3.1	0.2
Of which developments in prices for crude oil and natural gas	-0.1	0.1	0.0	-1.0	-0.3	-0.2	0.2	-0.2	1.7	3.9	1.7	0.1	-0.6	0.4	-0.5	-9.2	-2.4	-2.9	1.8	1.7	-1.6	-2.0	-0.2
Balance of income and current transfers	0.4	-0.3	-0.2	-0.3	-0.3	-0.7	-1.1	-1.0	-1.0	0.3	-0.2	-0.5	0.4	0.2	1.0	0.1	0.2	-1.1	-0.4	-0.4	-0.6	1.2	-0.3

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014*	2015*
Real disposable income	4.5	5.6	9.1	6.4	-2.3	7.2	16.5	1.5	-2.8	0.9	8.4	11.3	6.8	0.9	5.9	-11.1	3.3	4.9	3.8	0.6	3.5	-3.8
Contribution from production growth in petroleum activities	2.1	1.2	1.5	0.8	-1.0	-0.1	0.7	0.9	0.3	0.3	0.1	-1.3	-1.7	-1.5	-0.9	-0.5	-1.2	-0.9	-0.4	-1.2	0.0	0.8
Other production growth	4.0	3.5	4.1	5.0	3.4	1.7	2.6	1.0	0.9	0.5	4.4	3.9	3.9	4.2	0.6	-2.2	1.3	1.7	3.3	1.9	1.9	0.7
Change in terms of trade	-1.8	0.4	3.0	0.7	-4.5	5.3	14.1	-1.9	-4.1	0.0	4.2	7.4	5.9	-1.2	6.4	-9.1	2.7	4.4	1.0	-0.1	-2.3	-5.6
Of which developments in prices for crude oil and natural gas	-1.8	-0.9	3.3	-0.1	-4.6	4.1	12.8	-2.9	-4.0	-0.1	3.7	6.4	4.7	-1.3	6.0	-8.2	2.0	4.8	1.0	-0.4	-2.1	-4.8
Balance of income and current transfers	0.3	0.4	0.4	0.0	-0.2	0.4	-0.8	1.5	0.0	0.2	-0.2	1.2	-1.3	-0.5	-0.2	0.8	0.4	-0.2	0.0	0.0	3.8	0.3

* Preliminary figures

Source: Statistics Norway

Figure 2.1 Accumulated growth in real per capita disposable income since 1970. In 1000s of NOK. 2015 prices



Source: Statistics Norway.

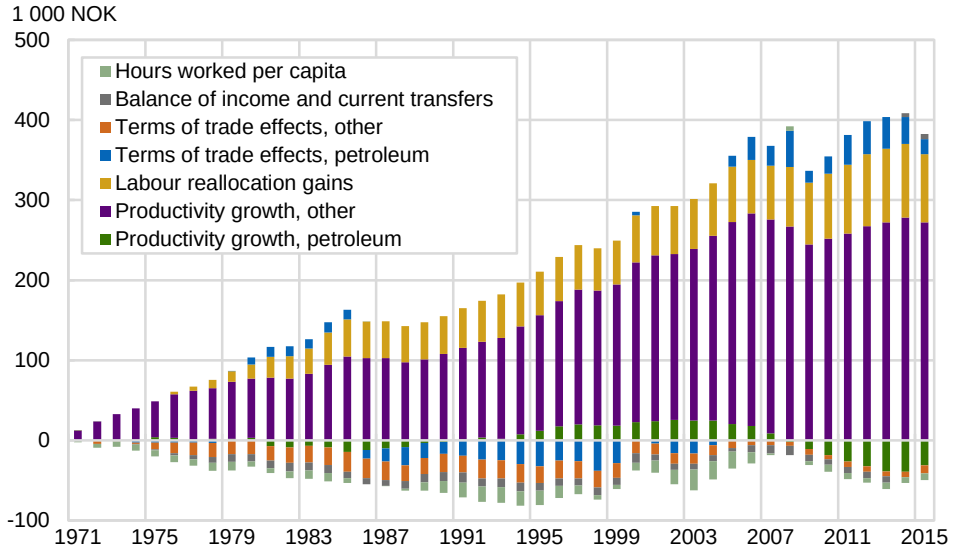
Figure 2.2 shows a decomposition of accumulated growth in real per capita disposable income since 1970 measured in 2015 prices. There are seven contributory factors in Figure 2.2: productivity in oil and gas extraction; productivity in non-petroleum industries; labour reallocation gains; terms of trade effects from petroleum products; terms of trade effects from non-petroleum products; balance of income and current transfers; and hours worked per capita. Since the figure shows the accumulated contributions to growth, this means that the

contributory factors in 2015 add up to the total increase in real per capita disposable income from 1970 to 2015 of NOK 334 000 in total.[3]

In the period 1970–2015, four income components have made a positive contribution. The main contribution to real disposable income growth is attributable to productivity growth in industries other than oil and gas extraction. This productivity growth has contributed a total of NOK 272 000 of the real disposable income growth of NOK 334 000 in total over the period 1970–2015. The second most important contribution to income growth comes from labour reallocation gains. This component is a result of the reallocation of labour to petroleum activities from non-petroleum industries. As the profitability of oil and gas extraction has been generally higher than that of non-petroleum industries, the reallocation of labour has contributed positively to income growth. An important reason for the high profitability is the resource rent, i.e. the income attributable to natural resources alone. The accumulated contribution from reallocations was NOK 85 000. Terms of trade gains attributable to petroleum price developments constitute the third most important contributory factor, and amounted to NOK 19 000. The contribution from balance of income and current transfers was NOK 6 000. The contributions from hours worked per capita, terms of trade losses on non-petroleum products and productivity growth in oil and gas extraction to income development through the period were negative, however.

The decomposition in Figure 2.2 differs from Table 2.1 in that it takes as it's starting point Norway's real disposable income as shown in Table 2.1 and distributes it per capita. A further decomposition is also performed by including gains attributable to reallocation of labour among industry groups. In the per capita analysis, the accumulated growth contributions over the entire period are measured in 2015 prices, and not as contributions to growth relative to the previous period measured in percentage points, as in Table 2.1.

Figure 2.2 Decomposition of accumulated growth in real per capita disposable income since 1970. In 1000s of NOK



Source: Statistics Norway

[3] There is a negligible discrepancy, which is described in more detail in Chapter 3.

3. Contributions to growth in Norway's real disposable income

Table 2.1 shows growth in Norway's real disposable income and contributions to this growth. In order to derive the decomposition in the table, we take as our starting point a definition of disposable income. Norway's disposable income can be written as the sum of net national product[4] and balance of income and current transfers. Table 3.1 shows net national product, balance of income and current transfers and Norway's disposable income for the years 2006–2015. The balance of income and current transfers is split up into subcomponents in the table. The balance of income and current transfers represents transfers from abroad less transfers to other countries, such as capital income, wages, benefits etc.

Table 3.1. Disposable income, balance of income and current transfers and net national product. Billions of NOK

	2006	2007	2008	2009	2010	2011	2012	2013	2014*	2015*
Gross domestic product	**2 215**	**2350**	**2605**	**2430**	**2590**	**2792**	**2965**	**3071**	**3154**	**3131**
- Consumption of fixed capital	298	331	367	396	413	436	459	482	514	546
Net national product	**1917**	**2019**	**2239**	**2034**	**2177**	**2356**	**2506**	**2589**	**2640**	**2585**
Balance of income and current transfers	**-18**	**-28**	**-33**	**-16**	**-8**	**-14**	**-15**	**-14**	**87**	**98**
+ Capital income and wages from abroad	198	247	249	172	212	220	248	245	314	336
- Capital income and wages to other countries	196	255	261	159	184	193	223	213	178	182
+ Current transfers from abroad	17	19	20	20	20	21	25	27	32	32
- Current transfers to other countries	36	39	41	50	56	61	64	74	81	89
= Disposable income	**1 900**	**1991**	**2205**	**2018**	**2169**	**2343**	**2491**	**2575**	**2727**	**2683**

* Preliminary figures.
Source: Statistics Norway

Net national product measures overall economic activity in Norway and provides an expression of the economic value-added that is earned through production less consumption of fixed capital. Table 3.1 shows that Norway's income derives almost entirely from production. In 2015, net national product was NOK 2 585 billion according to preliminary figures. By way of comparison, the balance of income and current transfers amounted to only NOK 98 billion in 2015. The relatively large net capital income from interest, share dividends and reinvested earnings can be attributed largely to income from the Government Pension Fund Global. Capital income is offset to some extent by current transfers, for example for development aid, and membership fees to the EU and the UN, among others. In 2015, Norway's disposable income was NOK 2 683 billion.

The relationship between disposable income (DI), net national product (NNP) and balance of income and current transfers (RSB) in period t can be written as:

$$DI_t = NNP_t + RSB_t. \quad (1)$$

When developments in disposable income over time are studied, it is real income that is interesting. This is arrived at by adjusting disposable income for the rise in prices for goods and services that have been used in Norway. This price correction provides a measure of how many 'baskets' with an average composition of goods and services the income could have bought. Here, 'expenditure' encompasses both consumption and investment in real capital. One reason why we look at domestic

[4]Net national product (NNP) = gross domestic product (GDP) – consumption of fixed capital. The focus here is on contributions to NNP, but the decomposition above can be generalised by splitting up the contribution from NNP into the separate contributions from GDP and consumption of fixed capital.

expenditure, and not just consumption, is that investment makes future consumption possible. For example, Weitzman (1976) shows that domestic final expenditure is a measure of the economy's ability to maintain constant consumption over time. When the price index for net domestic final expenditure is used, growth in real income will therefore measure how many more goods and services that can be purchased, given that it must also be possible to maintain this consumption over time[5]. If P_t^D indicates the price index for net domestic final expenditure between period $t-1$ and period t, then DI_t/P_t^D represents real disposable income. The percentage growth in real disposable income can then be written $\frac{(DI_t/P_t^D)-DI_{t-1}}{DI_{t-1}}$ and it is this that is shown in Table 2.1. From equation (1), the percentage growth can be decomposed further into contributions from net national product and balance of income and current transfers

$$\frac{(DI_t/P_t^D)-DI_{t-1}}{DI_{t-1}}=\frac{(\mathrm{NNP_t}/P_t^D)-NNP_{t-1}}{DI_{t-1}}+\frac{[(\mathrm{RSB}_t/P_t^D)-RSB_{t-1}]}{DI_{t-1}}. \quad (2)$$

In Table 2.1, growth in real disposable income is decomposed into contributions from production growth, terms of trade gains/losses in addition to changes in balance of income and current transfers. It is the first expression after the equals sign in equation (2), the contribution from net national product, which can be decomposed further into contributions from production growth and terms of trade effects. To see this, note that the contribution from NNP can be written as

$$\frac{(\mathrm{NNP_t}/P_t^D)-NNP_{t-1}}{DI_{t-1}}=\left(\frac{NNP_{t-1}}{DI_{t-1}}\right)\left(\frac{\mathrm{NNP_t}/P_t^D}{NNP_{t-1}}-1\right). \quad (3)$$

The contribution from net national product is thus the real growth in NNP when it is deflated by the price index for net domestic final expenditure, where this growth is weighted by the share of disposable income in the net national product. In order to single out the contribution from production in constant prices, the last expression can be written as the sum of volume growth in NNP and an expression we usually call terms of trade effects; i.e.

$$\begin{aligned}\left(\frac{\mathrm{NNP_t}/P_t^D}{NNP_{t-1}}-1\right)&=\left(\frac{\mathrm{NNP_t}/P_t^{NNP}}{NNP_{t-1}}-1\right)\\&+\left[\left(\frac{\mathrm{NNP_t}/P_t^D}{NNP_{t-1}}\right)-\left(\frac{\mathrm{NNP_t}/P_t^{NNP}}{NNP_{t-1}}\right)\right],\end{aligned} \quad (4)$$

where $P_t^{NNP}$is the price index for net national product. This can also be written as

$$Q_t^{NNP,P^D}=Q_t^{NNP}+\left[Q_t^{NNP,P^D}-Q_t^{NNP}\right], \quad (5)$$

where $Q_t^{NNP,P^D}=\frac{\mathrm{NNP_t}/P_t^D}{NNP_{t-1}}-1$ and $Q_t^{NNP}=\frac{\mathrm{NNP_t}/P_t^{NNP}}{NNP_{t-1}}-1$. The first expression represents growth in NNP volume as the value in period t is deflated by the price index for NNP. The last expression in square brackets represents terms of trade effects.

To illustrate why the two expressions in the square brackets can be interpreted as terms of trade effects, the two expressions can be written explicitly, in order to reveal the difference between them. Net national product can be written as the sum

[5] Net domestic final expenditure = domestic final expenditure - consumption of fixed capital

of domestic expenditure and exports, less imports. Let p and q represent prices and quantity, respectively. Net national product in current prices can then be written as

$$NNP_t = p_{Dt}q_{Dt} + p_{Xt}q_{Xt} - p_{Mt}q_{Mt,}$$

where D represents domestic expenditure, X represents exports and M represents imports. The volume index for net national product can be written as

$$Q_t^{NNP} = \frac{\mathrm{NNP_t}/P_t^{NNP}}{NNP_{t-1}} - 1 = \frac{p_{Dt-1}q_{Dt} + p_{Xt-1}q_{Xt} - p_{Mt-1}q_{Mt}}{p_{Dt-1}q_{Dt-1} + p_{Xt-1}q_{Xt-1} - p_{Mt-1}q_{Mt-1}} - 1$$
$$= \frac{p_{Dt}q_{Dt}/P_t^D + p_{Xt}q_{Xt}/P_t^X - p_{Mt}q_{Mt}/P_t^M}{NNP_{t-1}} - 1.$$

The expression after the second equals sign shows volume growth in NNP as a Laspeyres volume index; in other words, one looks at the change in volumes on the basis of the price level from period $t-1$. The expression after the third equals sign shows the volume contributions of domestic spending, exports and imports.

The purpose of calculating the contribution of terms of trade effects is to show the amount of domestic spending made possible by net exports. It is then reasonable to deflate by the rise in prices for the goods and services that are typically used, and it is therefore logical to use the deflator for net domestic final expenditure P_t^D. The choice of deflator for net exports has been a matter of controversy in the literature, and this choice also depends on the specific question posed. In the *System of National Accounts 2008* (SNA), statistics agencies have the option of choosing the deflator they believe best lends itself to illustrating developments in real income.[6] Statistics Norway uses the deflator for net domestic final expenditure.

The expression for growth in NNP deflated by the price index for net domestic final expenditure can then be written

$$Q_t^{NNP,P^D} = \frac{\mathrm{NNP_t}/P_t^D}{NNP_{t-1}} - 1 = \frac{p_{Dt}q_{Dt}/P_t^D + p_{Xt}q_{Xt}/P_t^D - p_{Mt}q_{Mt}/P_t^D}{NNP_{t-1}} - 1.$$

The difference between growth in NNP volume and real NNP growth when it is deflated by the price index for net domestic final expenditure is then

$$\left[Q_t^{NNP,P^D} - Q_t^{NNP}\right] = \frac{[(p_{Xt}q_{Xt} - p_{Mt}q_{Mt})/P_t^D] - [p_{Xt}q_{Xt}/P_t^X - p_{Mt}q_{Mt}/P_t^M]}{NNP_{t-1}}$$
$$= TGI_t.$$

This expression represents terms of trade effects. If the rise in prices for the goods we consume and invest is lower than for the goods we export, $P_t^D < P_t^X$, the result is a terms of trade gain. We then get more goods for consumption and investment in return for the goods we export. These terms of trade effects are normally called "trading gains indices" in economics literature; see for example Reinsdorf (2010) or Cao and Kozicki (2016). A good description of how to calculate the effect of changes in export and import prices on real disposable income is also provided in Chapter 24 of ILO et al., (2009).

The terms of trade effects can be further decomposed into contributions from petroleum products and non-petroleum products. Let o represent petroleum, and let e represent all non-petroleum products. Then

[6] If the statistics agency is uncertain which index to use to calculate the contribution from terms of trade gains/losses, the SNA recommends using an average of the import and export price indices (European Commission et al., 2009, p. 317).

$$TGI_t = \gamma_{t-1}^e TGI_t^e + \gamma_{t-1}^o TGI_t^o,$$

where the weights $\gamma_t^i = \left(\frac{NNP_t^i}{NNP_t}\right)$ for $i = e, o$ are value shares of the net national product of the two *products*, $TGI_t^i = Q_t^{NNP,P^D,i} - Q_t^{NNP,i}$, $Q_t^{NNP,i} = \frac{NNP_t^i / P_t^{NNP,i}}{NNP_{t-1}^i} - 1$ and $Q_t^{NNP,P^D,i} = \frac{NNP_t^i / P_t^{D,i}}{NNP_{t-1}^i} - 1$ for $i = e, o$.

Growth in NNP can be broken down into the contributions to production of oil and gas extraction and of non-petroleum industries. This volume growth can be written as a weighted sum of growth in oil and gas extraction and growth in non-petroleum industries:

$$Q_t^{NNP} = \epsilon_{t-1}^e Q_t^{NNP,e} + \epsilon_{t-1}^o Q_t^{NNP,o}, \tag{6}$$

where the weights $\epsilon_t^i = \left(\frac{NNP_t^i}{NNP_t}\right)$ for $i = e, o$ are value shares of the net national product of the two *industries*.[7] To simplify the notation, we let w_t represent the net national product's share of disposable income, $w_t = \left(\frac{NNP_t}{DI_t}\right)$, and Q_t^{RSB} represent the contribution from balance of income and current transfers to real disposable income growth in equation (2), i.e. $Q_t^{RSB} = \frac{[(RSB_t / P_t^D) - RSB_{t-1}]}{DI_{t-1}}$. We further let $Q_t^{DI} = \frac{(DI_t / P_t^D)}{DI_{t-1}} - 1$ represent growth in real disposable income. When these relationships are inserted into equation (2), it follows that the contribution from NNP to growth in real disposable income can be written as

$$\begin{aligned} Q_t^{DI} = {} & w_{t-1}\epsilon_{t-1}^o Q_t^{NNP,o} + w_{t-1}\epsilon_{t-1}^e Q_t^{NNP,e} + w_{t-1}\gamma_{t-1}^o TGI_t^o \\ & + w_{t-1}\gamma_{t-1}^e TGI_t^e + Q_t^{RSB}. \end{aligned} \tag{7}$$

This decomposition shows contributions to growth in real disposable income from production growth in oil and gas extraction, other production growth, terms of trade effects from petroleum products, terms of trade effects from non-petroleum products and change in balance of income and current transfers. The decomposition in equation (7) coincides with the decomposition in Table 2.1, except that the contribution from the overall change in terms of trade ($w_{t-1}TGI_t$) is shown in the table in addition to the individual contribution from petroleum extraction ($w_{t-1}\gamma_{t-1}^o TGI_t^o$).[8] Note that even though Table 2.1 says contribution from "production growth", this is actually a contribution from the *value added* of production activity measured in terms of net product. Net product is the value of production less the value of intermediate inputs and consumption of fixed capital.

4. Decomposition of accumulated growth in real per capita disposable income

The purpose of this section is to show how real per capita disposable income can be decomposed as shown in Figure 2.2. The contributions in Figure 2.2 include productivity effects. The productivity concept we use is labour productivity. H_t represents the sum of hours worked in period t, and the growth in volume of hours worked is represented by $Q_t^H = \frac{H_t}{H_{t-1}} - 1$. We define growth in labour productivity as the difference between growth in volume of the value-added of production and

[7] The difference between the weights γ_t^i and ϵ_t^i is that the former relates to products while the latter relates to industries.

[8] The calculations may deviate somewhat from equation (7) in the year two years after the last final year; see Appendix B.

growth in hours worked. We measure the value-added of production through the net product, and growth in labour productivity can thus be written as[9]

$$\text{Growth in labour productivity} = Q_t^{NNP} - Q_t^H. \tag{8}$$

Growth in hours worked can also be decomposed into the contribution from oil and gas extraction and that from non-petroleum industries

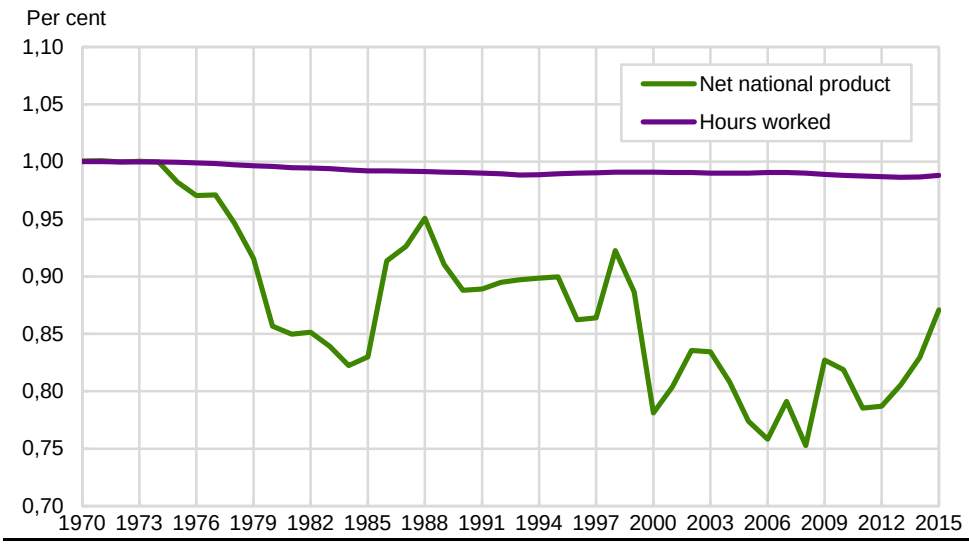
$$Q_t^H = \delta_{t-1}^e Q_t^{H,e} + \delta_{t-1}^o Q_t^{H,o}, \tag{9}$$

where the weights $\delta_t^i = \left(\frac{H_t^i}{H_t}\right)$ for $i = e, o$ are percentages of hours worked. By inserting (9) and (6) into (8), aggregate productivity growth can then be decomposed into three contributions

$$\begin{aligned} Q_t^{NNP} - Q_t^H &= \epsilon_{t-1}^e \left(Q_t^{NNP,e} - Q_t^{H,e}\right) + \epsilon_{t-1}^o \left(Q_t^{NNP,o} - Q_t^{H,o}\right) \\ &+ \left[(\epsilon_{t-1}^e - \delta_{t-1}^e)\left(Q_t^{H,e} - Q_t^{H,o}\right)\right]. \end{aligned} \tag{10}$$

The first expression after the equals sign, $\epsilon_{t-1}^e \left(Q_t^{NNP,e} - Q_t^{H,e}\right)$, represents the growth contribution from productivity growth in non-petroleum industries, $\epsilon_{t-1}^o \left(Q_t^{NNP,o} - Q_t^{H,o}\right)$, shows the contribution to growth of productivity growth in oil and gas extraction and the last expression, $\left[(\epsilon_{t-1}^e - \delta_{t-1}^e)\left(Q_t^{H,e} - Q_t^{H,o}\right)\right]$, represents the contribution attributable to resources having been reallocated to more (or less) profitable industries. Here profitability is represented by the difference in the shares $(\epsilon_{t-1}^e - \delta_{t-1}^e)$. Figure 4.1 shows shares of both net product, ϵ_{t-1}^e, and hours worked, δ_{t-1}^e, in non-petroleum industries as a share of net national product and total hours worked for Norway. The difference between these shares, $(\epsilon_{t-1}^e - \delta_{t-1}^e)$, has been negative throughout the period. It is mainly the share of net product that is relatively large in oil and gas extraction compared with non-petroleum industries. A transfer of resources to petroleum activities $\left(Q_t^{H,e} - Q_t^{H,o}\right) < 0$ has therefore led to positive labour reallocation gains as shown in Figure 2.2. In 2015, the accumulated contribution from labour reallocation gains was NOK 85 000. An important reason for the positive labour reallocation gains is the economic rent, i.e. the income attributable to natural resources alone.

Figure 4.1 Net national product and hours worked in non-petroleum industries. Percentages of total net national product and hours worked



Source: Statistics Norway

[9] An alternative is to measure the value-added of production in terms of gross product.

The contribution of labour productivity to real per capita disposable income is obtained by rewriting equation (7). Let B_t represent the population in period t and $Q_t^B = \frac{B_t}{B_{t-1}} - 1$ represent population growth. Complete decomposition of growth in real per capita disposable income is achieved by adding and subtracting both Q_t^B and Q_t^H and inserting equation (10) into equation (7):

$$\begin{aligned} Q_t^{DI} - Q_t^B = & \left[w_{t-1}\epsilon_{t-1}^o\left(Q_t^{NNP,o} - Q_t^{H,o}\right)\right] + \left[w_{t-1}\epsilon_{t-1}^e\left(Q_t^{NNP,e} - Q_t^{H,e}\right)\right] \\ & + \left[w_{t-1}(\epsilon_{t-1}^e - \delta_{t-1}^e)\left(Q_t^{H,e} - Q_t^{H,o}\right)\right] + \left[w_{t-1}\gamma_{t-1}^o TGI_t^o\right] \\ & + \left[w_{t-1}\gamma_{t-1}^e TGI_t^e\right] + \left[Q_t^{RSB}\right] + \left[Q_t^H - Q_t^B\right] + \left[(w_{t-1} - 1)Q_t^H\right]. \end{aligned}$$

The decomposition shows 8 contributions: 1) productivity in oil and gas extraction, 2) productivity in non-petroleum industries, 3) labour reallocation gains, 4) terms of trade effects from petroleum products, 5) terms of trade effects from non-petroleum products, 6) balance of income and current transfers, 7) hours worked per capita and 8) a residual. The residual represents a wedge that arises as a result of the splitting up of growth in per capita disposable income into contributions from hours worked per capita and productivity. This expression will be of negligible significance as there is so little difference between disposable income and net national product. For example, net national product was 96.2 per cent of disposable income in 2015; see Table 3.1. Growth in hours worked for 2015 must be weighted with $w_{t-1} - 1 = (0.962 - 1) = -0.038$. Growth in hours worked was 0.6 per cent in 2015 and the contribution from this wedge is then $0.006 * (-0.038) = -0.0002$, or -0.02 percentage points, which is negligible.

There is a difference between the decomposition above and the decomposition in Figure 2.2. The decomposition above is based on growth from one period to the next, decomposed into contributions measured in percentage points. The decomposition in Figure 2.2, however, shows the *accumulated* contributions from growth from 1970 measured in 2015 kroner. Two operations are required to go from the decomposition above to an expression that describes the decomposition in Figure 2.2: a) chain the indices and b) calculate the percentages of the chained components of total growth.

For it to be possible to accumulate the growth contributions over time, the contributions to growth in the equation above must be chained. Let z_{it} for $i = 1,2,\dots,8$ represent the 8 different contributions to growth in the equation, and let z_t designate aggregate growth, $z_t = \sum_i z_{it}$, i.e. growth in real per capita disposable income. Further, let z_{it} represent the chained index with reference point in 1970. The chained index is found by putting $iz_{it} = 1$ for $t = 1970$ and then using the formula $iz_{it} = iz_{it-1}(1 + z_{it})$ for $t = 1971, 1972, \dots, T$. For example, the value of the chained index for productivity growth in oil and gas extraction $iz_{1t} = 0.908$ in $t = 2015$. This means that the average annual growth over a period of 45 years has been about -0.2 per cent.

With this method, there will be a slight discrepancy between the product of the chained components and the aggregate chaining of per capita disposable income. $z_t = Q_t^{DI} - Q_t^B$ represents as mentioned growth in real per capita disposable income between two periods. Using notation similar to the above, iz_t then designates the chained index of real per capita disposable income relative to the reference year, 1970. iz_t therefore represents the correct index for growth in real per capita disposable income. When we calculate the contributory factors, however, we base ourselves on the chained indices from the individual contributions. There will be an approximation discrepancy between the product of the chained indices and the aggregate chained index, i.e. $iz_t \neq \prod_i iz_{it}$.

We call the difference between iz_t and $\prod_i iz_{it}$ an approximation discrepancy, because the discrepancy decreases as the growth rates approach 0.[10] In practice, the approximation is relatively good when the growth rates are lower than 10 per cent in an absolute sense. As a rule, the contributory factors z_{it} have had positive growth rates of less than 5 per cent and the discrepancy between the two expressions is therefore marginal. In 2015 the aggregate chained index was $iz_t = 2.816$. This shows that real per capita disposable income was 2.816 times as high in 2015 as in 1970. The product of the chained components was $\prod_i iz_{it} = 2.805$ in 2015. The difference between iz_t and $\prod_i iz_{it}$ was therefore only 0.4 per cent for this period.

The next step is to calculate the shares of the total accumulated growth represented by the growth contributions. Let $\widetilde{P_t^D}$ designate the price index for net domestic final expenditure with 2015 as reference year. This means that the value is 1 in 2015. In 1970 the value was 0.11. Prices were therefore approximately $1/\widetilde{P_{1970}^D} = 9$ times higher in 2015 than in 1970. The accumulated growth in real per capita disposable income since 1970 can therefore be written $DI_t/\widetilde{P_t^D} - DI_{1970}/\widetilde{P_{1970}^D}$. Since both income components are deflated by a price index with 2015 as reference year, accumulated growth is measured in 2015 kroner. In 2015, accumulated growth since 1970 was NOK 334 000 per capita in 2015 kroner; see Figure4.1.

The contributions from the 8 components to this growth are found by making the series

$$zb_{it} = \left(DI_t/\widetilde{P_t^D} - DI_{1970}/\widetilde{P_{1970}^D}\right)\frac{\ln(iz_{it})}{\sum_i \ln(iz_{it})}, \tag{11}$$

for all contributory factors $i = 1,2,\ldots,8$. Note that the last fraction that distributes the components' contributions uses the sum of the logarithms of the various components and not the logarithm of the aggregate chained index $\ln iz_t$. In this way, the marginal approximation discrepancy between $\ln iz_t$ and $\sum_i \ln(iz_{it})$ is distributed according to the size of the contributory factors; see discussion above.

Figure 2.2 consists of the series zb_{it} for $i = 1,2,\ldots,7$. The contribution from the wedge between disposable income and net national product (zb_{8t}) is not included in Figure 2.2. In 2015 this contribution amounted to a little over NOK 1000 of total growth of NOK 334 000.

[10] This can be seen by writing the two expressions explicitly. The aggregate index can then be written: $iz_t = iz_{t-1}(1 + z_t) = (1 + z_t)^{T-1}$. By using the definition $z_t = \sum_i z_{it}$, the first-order logarithmic approximation can be written: $\ln(iz_t) \approx (T-1)(\sum_i z_{it})$, as $\ln(1+z) \approx z$ when $z \approx 0$. The closer the growth rates z_{it} approach 0, the better the approximation becomes. Similarly, we can write the expression $\prod_i iz_{it} = \prod_i (1 + z_{it})^{T-1}$. The logarithm of this expression can be written as $\ln \prod_i iz_{it} = (T-1)(\sum_i \ln(1 + z_{it}))$ and the corresponding first-order logarithmic approximation can therefore be written as $\ln \prod_i iz_{it} \approx (T-1)(\sum_i z_{it})$. It follows then that $iz_t \approx \prod_i iz_{it}$ when the growth rates z_{it} are close to 0.

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Appendix A: Definitions

q Volume
p Price
t Period
T Final period
DI Disposable income
NNP Net national product
RSB Balance of income and current transfers
B Population
H Hours worked
D Domestic expenditure (excluding inventory changes and statistical discrepancies)
X Exports
M Imports
o Petroleum industry
e Non-petroleum industries
P_t Price index, with reference year in previous period: $P_t = p_t/p_{t-1}$
$\widetilde{P_t}$ Price index with reference year 2015: $\widetilde{P_t} = p_t/p_{2015}$

$\delta_t^i = \left(\frac{H_t^i}{H_t}\right)$ for $i = e, o$

$\epsilon_t^i = \left(\frac{NNP_t^i}{NNP_t}\right)$ for $i = e, o$, relates to industries

$\epsilon_{T-1*}^i = \epsilon_{T-1}^i \left(\frac{P_{T-1}^{NNP}}{P_{T-1}^{NNP,i}}\right)$

$\gamma_t^i = \left(\frac{NNP_t^i}{NNP_t}\right)$ for $i = e, o$, relates to products

$\gamma_{T*}^i = \gamma_{T-1}^i \left(\frac{P_{T-1}^{NNP}}{P_{T-1}^{NNP,i}}\right)$

$w_t = \left(\frac{NNP_t}{DI_t}\right)$

$Q_t^{DI} = \frac{DI_t/P_t^D}{DI_{t-1}} - 1$

$Q_t^{NNP} = \frac{\mathrm{NNP_t}/P_t^{NNP}}{NNP_{t-1}} - 1$

$Q_{T*}^{NNP} = \frac{\mathrm{NNP}_T/P_{T*}^{NNP}}{NNP_{T-1}} - 1$

$Q_t^B = \frac{B_t}{B_{t-1}} - 1$

$Q_t^H = \frac{H_t}{H_{t-1}} - 1$

$Q_t^{RSB} = \frac{\left[\left(RSB_t/P_t^D\right) - RSB_{t-1}\right]}{DI_{t-1}}$.

$TGI_t = \frac{\left[\left(p_{Xt}q_{Xt} - p_{Mt}q_{Mt}\right)/P_t^D\right] - \left[p_{Xt}q_{Xt}/P_t^X - p_{Mt}q_{Mt}/P_t^M\right]}{NNP_{t-1}} = \gamma_{t-1}^e TGI_t^e + \gamma_{t-1}^o TGI_t^o$ – trading gain index

$TGI_{T*} = \gamma_{T-1*}^e TGI_{T*}^e + \gamma_{T-1*}^o TGI_{T*}^o$,

$TGI_t^i = \frac{\left[\frac{\left(p_{Xt}^i q_{Xt}^i - p_{Mt}^i q_{Mt}^i\right)}{P_t^D}\right] - \left[\frac{p_{Xt}^i q_{Xt}^i}{P_t^{X,i}} - \frac{p_{Mt}^i q_{Mt}^i}{P_t^{M,i}}\right]}{NNP_{t-1}} = \left[Q_t^{NNP,P^D,e} - Q_t^{NNP,e}\right]$ for $i = e, o$

$z_{0t} = Q_t^{DI} - Q_t^B$ – Growth in real per capita disposable income
$z_{1t} = \left[w_{t-1}\epsilon_{t-1}^o\left(Q_t^{NNP,o} - Q_t^{H,o}\right)\right]$ – Productivity growth, petroleum
$z_{2t} = \left[w_{t-1}\epsilon_{t-1}^e\left(Q_t^{NNP,e} - Q_t^{H,e}\right)\right]$ – Productivity growth, other
$z_{3t} = \left[w_{t-1}\left(\epsilon_{t-1}^e - \delta_{t-1}^e\right)\left(Q_t^{H,e} - Q_t^{H,o}\right)\right]$ – Labour reallocation gains
$z_{4t} = \left[w_{t-1}TGI_t^o\right]$ – Terms of trade effects, petroleum
$z_{5t} = \left[w_{t-1}TGI_t^e\right]$ – Terms of trade effects, non-petroleum
$z_{6t} = \left[Q_t^{RSB}\right]$ – Balance of income and current transfers

$z_{7t} = [Q_t^H - Q_t^B]$ – Hours worked per capita
$z_{8t} = [(w_{t-1} - 1)Q_t^H]$ – Residual
$iz_{it} = iz_{it-1}(1 + z_{it})$ for $t = 1971, 1972, \dots, T, iz_{it} = 1$ in 1970, for $i = 1,2, \dots ,8$.
$zb_{it} = \left(DI_t/\widetilde{P_t^D} - DI_{1970}/\widetilde{P_{1970}^D}\right)\frac{\ln(iz_{it})}{\sum_i \ln(iz_{it})}$, for $i = 1,2, \dots ,8$.

Decomposition of growth in NNP into contributions from two industries:

$$Q_t^{NNP} = \frac{p_{Dt-1}^e q_{Dt}^e + p_{Xt-1}^e q_{Xt}^e - p_{Mt-1}^e q_{Mt}^e + p_{Dt-1}^o q_{Dt}^o + p_{Xt-1}^o q_{Xt}^o - p_{Mt-1}^o q_{Mt}^o}{p_{Dt-1}^e q_{Dt-1}^e + p_{Xt-1}^e q_{Xt-1}^e - p_{Mt-1}^e q_{Mt-1}^e + p_{Dt-1}^o q_{Dt-1}^o + p_{Xt-1}^o q_{Xt-1}^o - p_{Mt-1}^o q_{Mt-1}^o} - 1$$

$$= \frac{p_{Dt}^e q_{Dt}^e / P_t^{D,e} + p_{Xt}^e q_{Xt}^e / P_t^{D,e} - p_{Mt}^e q_{Mt}^e / P_t^{D,e}}{NNP_{t-1}} + \frac{+p_{Dt}^o q_{Dt}^o / P_t^{D,o} + p_{Xt}^o q_{Xt}^o / P_t^{D,o} - p_{Mt}^o q_{Mt}^o / P_t^{D,o}}{NNP_{t-1}} - 1$$

$$= \left(\frac{NNP_{t-1}^e}{NNP_{t-1}}\right) Q_t^{NNP,e} + \left(\frac{NNP_{t-1}^o}{NNP_{t-1}}\right) Q_t^{NNP,o}$$

where $Q_t^{NNP,e} = \frac{\mathrm{NNP}_t^e / P_t^{NNP,e}}{NNP_{t-1}^e} - 1$ and $Q_t^{NNP,o} = \frac{\mathrm{NNP}_t^o / P_t^{NNP,o}}{NNP_{t-1}^o} - 1$.

Decomposition of TGI into contributions from two products:

$$TGI_t = \frac{\left[\frac{(p_{Xt}^e q_{Xt}^e - p_{Mt}^e q_{Mt}^e)}{P_t^D}\right] - \left[\frac{p_{Xt}^e q_{Xt}^e}{P_t^{X,e}} - \frac{p_{Mt}^e q_{Mt}^e}{P_t^{M,e}}\right]}{NNP_{t-1}} + \frac{\left[\frac{(p_{Xt}^o q_{Xt}^o - p_{Mt}^o q_{Mt}^o)}{P_t^D}\right] - \left[\frac{p_{Xt}^o q_{Xt}^o}{P_t^{X,o}} - \frac{p_{Mt}^o q_{Mt}^o}{P_t^{M,o}}\right]}{NNP_{t-1}}$$

Appendix B: Decomposition of growth in real disposable income for the year two years after the last final year

The final annual accounts for a year are published 21 months after the end of the year. Until the final annual accounts are available, preliminary annual figures are calculated on the basis of quarterly national accounts. For the years in the time series up to and including the last final year of the national accounts (final accounts), the volume growth for the calculation year is calculated by dividing the figures for the calculation year expressed in the previous year's prices (i.e., constant price figures with $t-1$ as basis year) with the previous year's figures in current prices (i.e. the figures for the basis year in basis year prices). For the years after the last final year, however, the final year is used as fixed basis year up to 2 years ahead in time. This means that the constant price figures for the year 2 years after the last final year are expressed in year $T-2$ prices and it is these that are used in the calculations for year T, i.e. 2 years after the final year[11]. The fixed basis year for the year two years after the last final accounts entails using a slightly different technical calculation formula for the growth contributions in this last year.

The expression for growth in real disposable income will be different because of the practice of using a different price index in the last period. To illustrate this, it is useful to write out explicitly the formulae for the price and volume indices used in the national accounts. The price index P_t and the volume index Q_t+1 in the national accounts are given by a Paasche price index and a Laspeyres volume index respectively,

$$P_t = \frac{\sum_i p_{it}x_{it}}{\sum_i p_{it-1}x_{it}}, Q_t + 1 = \frac{\sum_i p_{it-1}x_{it}}{\sum_i p_{it-1}x_{it-1}}.$$

where p_{it} and x_{it} are price and volume, respectively, of product i in period t. It follows from these relationships that the product of the price and volume indices is the change in value from one period to the next, i.e.

$$P_t \times (Q_t + 1) = \frac{\sum_i p_{it}x_{it}}{\sum_i p_{it-1}x_{it-1}}.$$

This relationship is often called the *product test*. The expressions for the two indices above can also be written as a weighted sum of relative price and quantum changes

$$P_t = \left[\sum_i s_{it}\left(\frac{p_{it}}{p_{it-1}}\right)^{-1}\right]^{-1}, Q_t + 1 = \sum_i s_{it-1}(x_{it}/x_{it-1}),$$

where the weights are value percentages $s_{it} = \frac{p_{it}x_{it}}{\sum_i p_{it}x_{it}}$.

If we express the constant price figures in the period T in $T-2$ prices, the expression for volume index becomes somewhat different $Q_{T*} = \frac{\sum_i p_{iT-2}x_{iT}}{\sum_i p_{iT-2}x_{iT-1}} - 1$. In order for the product of price and volume index also to express the value change in period T, the price index must according to the product test be given by

[11] See Korsnes (2014) for a more detailed description of the calculation of quarterly national accounts.

$$P_{T*} = \frac{\frac{\sum_i p_{iT} x_{iT}}{\sum_i p_{iT-1} x_{iT-1}}}{Q_{T*}} = \left(\frac{\sum_i p_{iT} x_{iT}}{\sum_i p_{iT-2} x_{iT}}\right)\left(\frac{\sum_i p_{iT-1} x_{iT-1}}{\sum_i p_{iT-2} x_{iT-1}}\right)^{-1} = P_{T,T-2*}/P_{T-1}.$$

The first expression in brackets after the second equals sign shows price developments over two periods, from period $T-2$ to period T, when the volumes from period T are kept constant. The second expression in brackets after the second equals sign shows price developments between period $T-2$ and $T-1$ when the volumes from period $T-1$ are kept constant. The relationship between the two expressions in brackets therefore indicates price developments from period $T-1$ to period T, but the weights are different from the Paasche index above. In the equation above, after the third equals sign we have defined $P_{T,T-2*} = \left(\frac{\sum_i p_{iT} x_{iT}}{\sum_i p_{iT-2} x_{iT}}\right)$ and $P_{T-1} = \left(\frac{\sum_i p_{iT-1} x_{iT-1}}{\sum_i p_{iT-2} x_{iT-1}}\right)$. The relationship above shows that the price index that is used is transitive, i.e. the price index over two periods is the product of the price indices in the two periods. The relationship also shows that the price index in period $T-1$ is the usual Paasche index. It therefore follows that the volume index Q_{T*} can be written in "the usual way", with the numerator deflated by the price index in question

$$Q_{T*} = \frac{\sum_i p_{iT-2} x_{iT}}{\sum_i p_{iT-2} x_{iT-1}} - 1 = \frac{\sum_i p_{iT} x_{iT} \,/ P^*_{T,T-2}}{(\sum_i p_{iT-1} x_{iT-1}) / \, P_{T-1}} - 1 = \frac{(\sum_i p_{iT} x_{iT})/(P_{T*})}{(\sum_i p_{iT-1} x_{iT-1})} - 1.$$

This last formulation is practical as it contains only value variables and a price index. It also illustrates the fact that the alternative expression for volume growth follows the same notation as in Chapter 3. For example, growth in disposable income will be given by $Q^{DI}_{T*} = \frac{DI_T/P_{T*}}{DI_{T-1}} - 1$, and aggregate growth in NNP will be given by $Q^{NNP}_{T*} = \frac{\mathrm{NNP}_T/P^{NNP}_{T*}}{NNP_{T-1}} - 1$.

When growth in NNP is decomposed into contributions from petroleum production and from non-petroleum industries, the expressions will be different from in Chapter 3, however. This is due to the manner in which the different growth contributions are to be weighted together. In order to see this, note that volume growth can be written as a weighted average of the underlying growth rates

$$Q_{T*} = \frac{\sum_i p_{iT-2} x_{iT}}{\sum_i p_{iT-2} x_{iT-1}} - 1 = \sum_i s_{iT-1*}\left(\frac{x_{iT}}{x_{iT-1}}\right) - 1,$$

the weights now being given by $s_{iT-1*} = \frac{p_{iT-2} x_{iT-1}}{\sum_i p_{iT-2} x_{iT-1}} = s_{iT-1}\left(\frac{P_{T-1}}{P_{iT-1}}\right)$. The difference between the weights used in Chapter 3 and these weights is that the date of the prices is a period earlier than the volumes. This results in a discrepancy consisting of the ratio between the aggregate rise in prices and the rise in prices for the individual product i[12].

The expression above can be compared with the decomposition in Chapter 3 of growth contributions from production in oil and gas extraction $Q^{NNP,o}_{T*}$ and non-petroleum industries $Q^{NNP,e}_{T*}$. The corollary to the decomposition above will accordingly be that total production can be decomposed into contributions from oil and gas extraction and from non-petroleum industries

$$Q^{NNP}_{T*} = \epsilon^{e}_{T-1*} Q^{NNP,e}_{T*} + \epsilon^{o}_{T-1*} Q^{NNP,o}_{T*},$$

[12] See Hernæs (2011) for a more detailed description of the chaining discrepancy.

where the weights $\epsilon^i_{T-1*} = \epsilon^i_{T-1}\left(\frac{P^{NNP}_{T-1}}{P^{NNP,i}_{T-1}}\right)$ and $Q^{NNP,i}_{T*} = \frac{NNP^i_T/P^{NNP,i}_{T*}}{NNP^i_{T-1}} - 1$ for $i = e, o$.

The situation is similar for the decomposition of the terms of trade effects. The overall terms of trade effects can be decomposed into contributions from petroleum products and from non-petroleum products according to the formula

$$TGI_{T*} = \gamma^e_{T-1*}TGI^e_{T*} + \gamma^o_{T-1*}TGI^o_{T*},$$

where the weights $\gamma^i_{T*} = \gamma^i_{T-1}\left(\frac{P^{NNP}_{T-1}}{P^{NNP,i}_{T-1}}\right)$ for $i = e, o$ are value shares of the net national product of the two *products*, $I^i_{T*} = Q^{NNP,P^D,i}_{T*} - Q^{NNP,i}_{T*}$, $Q^{NNP,i}_{T*} = \frac{NNP^i_T/P^{NNP,i}_{T*}}{NNP^i_{T-1}} - 1$ and $Q^{NNP,P^D,i}_{T*} = \frac{NNP^i_T/P^{D,i}_{T*}}{NNP^i_{T-1}} - 1$ for $i = e, o$.

It follows from the derivation above that the alternative decomposition in the last period can be written as

$$Q^{DI}_{T*} = w_{T-1}\epsilon^o_{T-1*}Q^{NNP,o}_{T*} + w_{T-1}\epsilon^e_{T-1*}Q^{NNP,e}_{T*} + w_{T-1}\gamma^o_{T-1*}TGI^o_{T*} + w_{T-1}\gamma^e_{T-1*}TGI^e_{T*} + Q^{RSB}_{T*}.$$

The main difference between equation (7) in Chapter 3 and this expression is the weights ϵ^i_{T-1*} and γ^i_{T-1*}. The wedge between these weights and the weights in the main text are due to the fact that the prices are dated in a period earlier in ϵ^i_{T-1*} and γ^i_{T-1*} than the weights in Chapter 3. The expressions for the volume growth rates Q^{DI}_{T*}, $Q^{NNP,o}_{T*}$, $Q^{NNP,e}_{T*}$, TGI^o_{T*}, TGI^e_{T*} and Q^{RSB}_{T*} are the same as in the main text, except that they have been deflated by the alternative price index P_{T*} instead of the price index P_T .

Statistics Norway

Postal address:
PO Box 8131 Dept
NO-0033 Oslo

Office address:
Akersveien 26, Oslo
Oterveien 23, Kongsvinger

E-mail: ssb@ssb.no
Internet: www.ssb.no
Telephone: + 47 62 88 50 00

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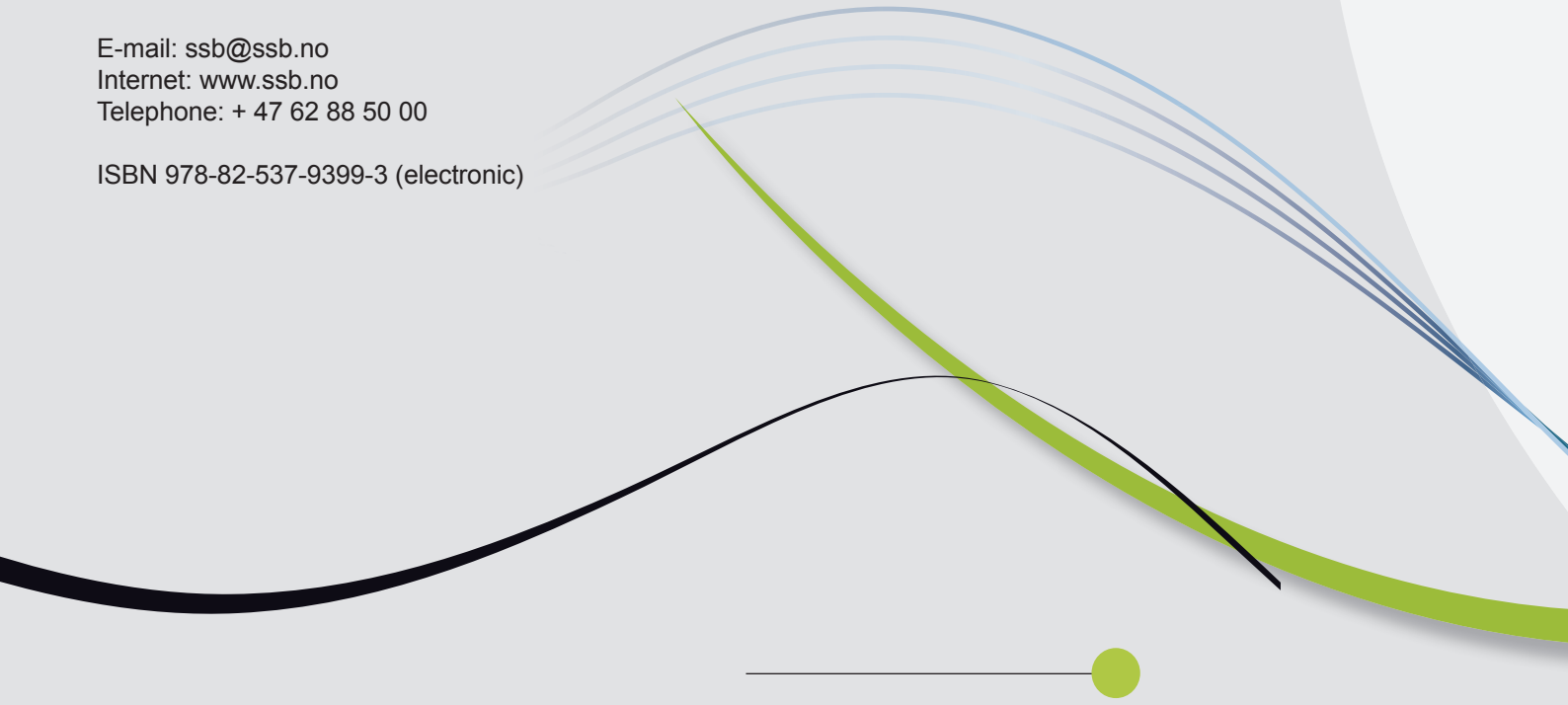

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