Norges Bank

5 | 2024

Staff memo

Charting the upstream:
An indicator for imported input goods prices

23.10.2024

Leif Brubakk
Kristine Aunvåg Matsen
Kristin Mjølnerød
Ørjan Robstad
Elisabeth Werenskiold

ISSN 1504-2596 (online)
ISBN 978-82-8379-338-3 (online)

Abstract

This Staff Memo presents an indicator used for monitoring and forecasting inflation at Norges Bank. The indicator is designed to capture international price impulses that impact the input costs of domestic firms. Our analysis indicates that the marked increase in the cost of imported intermediate goods over the last couple of years can account for parts of the rise in Norwegian CPI-inflation in the same period. The results suggest that changes to the price of products at early stages in the production chain can lead to changes in CPI, also making the indicator useful for forecasting.

1 Introduction

Inflation over the past few years has largely been driven by a series of abrupt inflationary shocks. The Covid pandemic led to a pronounced shift in spending from services to goods, both in Norway and internationally. This contributed to global supply bottlenecks, soaring freight rates and a steep rise in imported goods prices. Furthermore, the war in Ukraine put pressure on gas prices and contributed to record-high electricity prices in many countries. These factors have contributed both directly and indirectly to driving up consumer price inflation that can be understood as first-round effects. Gradually, price increases have also given rise to secondary effects through, for example, higher wage growth, as workers have been seeking compensation for higher cost of living.

The direct drivers of inflation, such as higher electricity prices, are relatively quickly reflected in the CPI. Meanwhile, indirect drivers are reflected in the CPI with a lag. These effects have largely been transmitted through commodities and imported intermediate goods via domestic production stages with further processing for final delivery of domestically produced goods and services.

In Norges Bank's modelling framework, direct international price impulses to imported consumer goods are well captured by our indicator for external price impulses to imported consumer goods (IPC) (Øverseth Røstøen (2004)), a composite measure weighing foreign prices across seven product groups from our main trading partners. However, recent events have underscored the inadequacy of the IPC in capturing impulses from abroad that also impact domestic prices, oftentimes through imported intermediaries.

To address this, we have developed a new metric, which was introduced in MPR 4/2023 (Norges Bank (2023)). The indicator for international price impulses to imported capital and intermediate goods (IPI) aims to account for the imported components of domestic firms' costs. That is, it is designed to capture some of the indirect international drivers of the price of domestically produced goods and services. Modelling the effects of imported intermediates on the domestic part of CPI presents challenges. Ideally, one would set up a detailed model of the production chain, accounting for the price impulses stemming from imported intermediates at every stage of the production chain. However, the required data are not readily available. Moreover, it is not obvious that this would improve the forecasting properties of our inflation models, given the added layers of uncertainty such a model would entail.

Consequently, our objective has been to devise an indicator capable of capturing a reduced-form mapping between imported intermediates and prices of domestically produced goods and services. The choice of indicator has been based on three criteria. First, the index should be based on easily accessible and regularly updated data. Second, the index should yield value added in explaining historical variation in the domestic part of CPI. Third, it should be forecastable by allowing for simple forecasting models to extrapolate developments of the index. The newly developed IPI meets all three criteria.

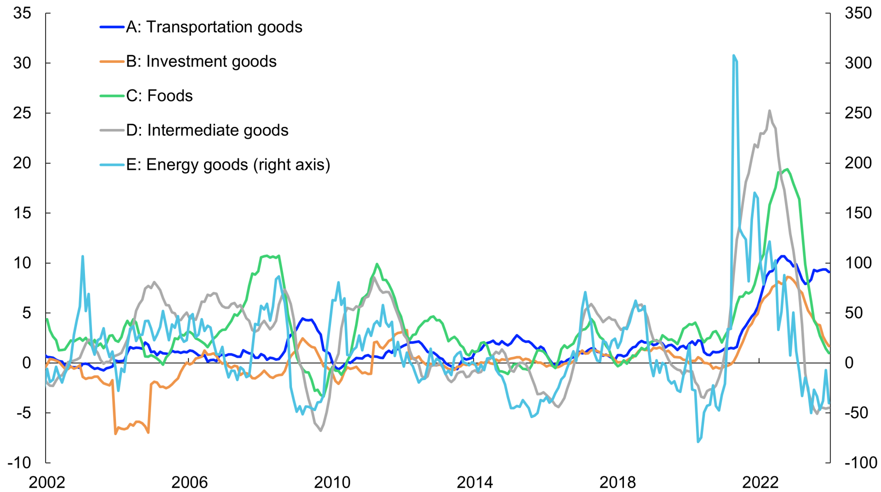

Figure 1: IPI subindices. Twelve-month growth. Percent

2 Construction of the indicator

To construct the IPI we primarily rely on international data on producer price indices (PPIs). Norway imports input goods from a range of countries. International price movements are not necessarily coordinated across these countries. We therefore use PPI-data for the five countries accounting for the highest share of imports within a given group of goods. The five biggest trading partners cover between 46 and 78 percent of the total imports for each of the product groups considered. The 17 product groups used to construct the IPI are grouped into five main sub-indices.[1]

- A: Transportation
- B: Investment goods
- C: Food goods
- D: Other intermediate goods
- E: Energy goods

Weights for the product groups and sub-indices are based on import volumes using data on the external trade in goods by end use (Statistics Norway (a)).[2] The sub-indices of IPI are constructed by aggregating relevant producer price indices (PPIs) for each product group in each sub-index. For IPI sub-index C, we use the food sub-index from the index for imported consumer goods (IPC),

[1] The five sub-indices mirror five of the groups in the statistics for "External trade in goods by end use" (table 05987 Statistics Norway (b)).

[2] At the sub-index level weights are constructed from using volume indices for imports by end use, from Statistics Norway's table 05987. Though end-use is the most appropriate categorisation for our purpose, more granular data on the product groups that enter and their import volumes across countries is not available using BEC classification. To remedy this we therefore approximate a mapping from the categorisation of goods by end-use to goods by commodity group, for which more detailed data is available. This approximation has its limitations. To capture as broad a set of potentially relevant early-stage goods, we thus also include some investment goods when backing out goods by end-use. At the product level, we derive relative weights using figures on imports from Statistics Norway's external trade in goods by commodity group (table 08809, Statistics Norway (a)).

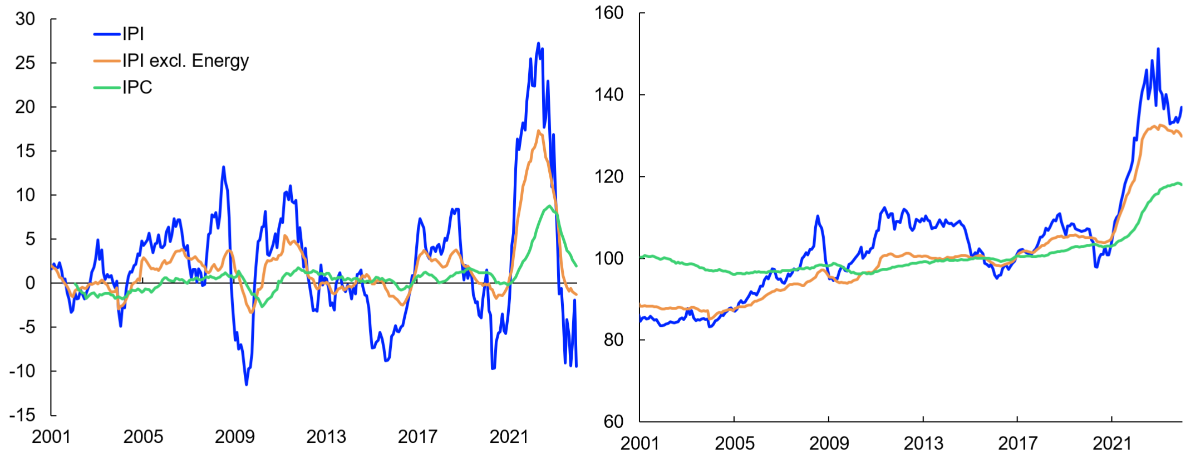

Figure 2: Aggregate IPI and IPC indices. Left: Twelve-month growth. Right: Index, 2015=100.

as this index already makes use of the relevant producer price indices. For sub-index E we do not utilize PPIs, instead opting for market prices. Sub-index E is constructed from two monthly series for the average spot price of Northsea Crude and Nordpool Electricity. Each sub-index is a weighted average of the prices that enter. In total, sub-index A, B and D utilise 70 PPI series from 19 countries. See appendix A for a complete overview of the construction of IPI.

The sub-indices are shown in figure 1. Sub-index E, covering energy goods, has been substantially more volatile than the other indices. Generally, the indices for food goods, energy goods and other intermediaries appear to move in similar cycles. For example, growth across all three of these indices declined steeply around 2008 and had a period of fairly high growth in 2017-2019. On the other hand, transportation goods and other capital goods have tended to follow somewhat different patterns.

The aggregate IPI index excluding energy had an average annual growth rate of about 1 percent between 2002 and 2019. However, the fluctuation around this level has at times been considerable, see figure 2. Comparing the growth rate of IPI to that of the IPC, see figure 2, shows that the two indices have followed similar patterns over time. However, we note that the average growth rate of the IPI has been higher. The amplitude of growth fluctuations are also larger. Additionally, though there are many common fluctuations across the indicators, changes in the IPI appear to lead changes in the IPC.

Starting in the beginning of 2021, the rate of growth of the IPI surged, peaking in the spring of 2022. Since then, the IPI indicates that input price pressures have cooled considerably, with negative twelve-month growth during the fall of 2023. Considering the IPI in level-terms, we see that despite the rapid decline in the twelve-month growth rate, IPI excluding energy remains at an elevated level, see figure 2. There has been a moderate decline from its peak level.

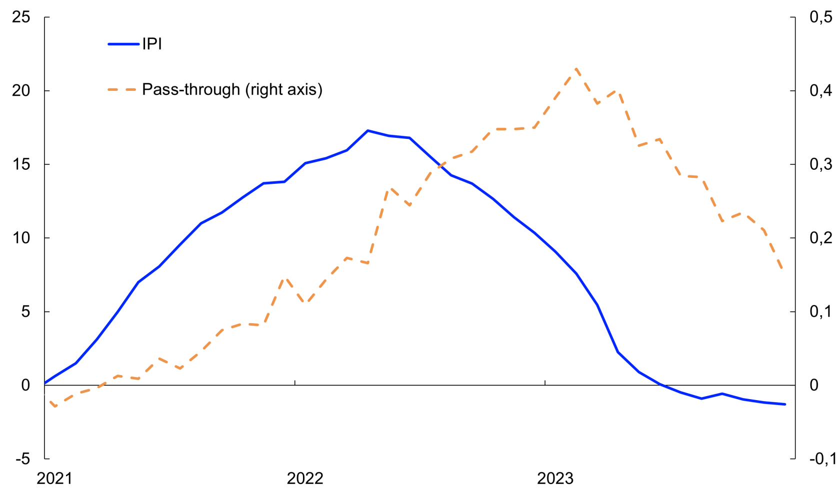

Figure 3: Contribution of IPI to underlying inflation (CPI-ATE)

3 Impact on CPI

Imported intermediate and capital goods enter the production chain at different stages, and it is reasonable to assume that there could be long lags between changes in the IPI and the impact on inflation. To deal with long lags, models with a rich dynamic structure are necessary. Bayesian VAR models with sufficiently long lags, extending many periods back in time, are well-suited to this purpose. We therefore use a BVAR model to quantify how changes in the IPI-index affects CPI, with a particular emphasis on domestically produced goods and services. In addition to the IPI the BVAR model includes six variables: domestic consumer prices (CPI-ATE domestic), import-weighted exchange rate (I-44), unit labor costs (ULC),[3] registered unemployment rate from NAV, energy prices and freight rates. The BVAR model is estimated using data in loglevels (except for the unemployment rate). The prior is a combination of the standard Minnesota prior (Doan et al., 1984), the sum-of-coefficients prior and dummy-initial-observation as in Giannone et al. (2015) and is estimated using monthly data from the period between January 2002 and December 2023. The lag length in the BVAR is 24 months.

We use historical counterfactual scenarios to illustrate the importance of IPI on domestic inflation in the BVAR. More specifically, we compare price developments under two different assumptions about movements in the IPI. In the first scenario, the IPI is assumed to rise in line with a trend growth of 2 percent annually between 2021 and 2023. In the second scenario, actual developments in the IPI are applied over the same period. For domestic inflation, we use the Kalman filter to estimate the most likely historical path, given the parameters of the BVAR in the two scenarios. This results in two different paths for the rise in prices for domestically produced goods and services. The difference between the two represents the estimated effect that the sharp rise in IPI has had on domestic prices since 2021. We aggregate to CPI-ATE in total by using the weights to domestic inflation (64.5 percent). The model exercise indicates that the IPI alone may explain about 0.4 percentage

[3] Unit labor costs are calculated using annual wage growth divided by a calculated trend in productivity. Productivity is defined as output (GDP mainland Norway) divided by employment.

point of the 12-month rise in the CPI-ATE in recent years, see figure 3.[4] It also indicates that the price of imported intermediaries affects inflation with a considerable lag. The largest impact on CPI-inflation was almost one year after the 12-month rise in the IPI peaked.

The results from the model exercise indicate that the IPI contribution was largest in the beginning of 2023. By taking into account developments in the IPI, we can therefore explain a larger share of the rise in inflation. In the model exercise described above, it is difficult to identify the effects of the IPI without including data for the most recent years. This is probably because imported intermediaries have not been a key driver of inflation in the decades preceding 2020. Based on the lessons from these model exercises, we are likely better equipped to project how future fluctuations in IPI affects the inflation outlook.

4 Forecasting the IPI

As described in section 3, the IPI can help explain part of the sharp rise in consumer price growth over the 2022-2023 period. This indicates that following such an index could be a useful tool when constructing projections for Norwegian CPI. To aid in forecasting inflation, we want to both account for the most recent development of the IPI, as well as how we expect it to evolve going forward. To do so, we also develop a simple framework for forecasting the future evolution of the IPI.

Our baseline model for forecasting the IPI is a simple AR-model, in which only the IPI in itself enters as an explanatory variable. We evaluate this model against a set of BVAR models that also use commodity prices to forecast the evolution of the IPI. Commodity prices are relevant for the future evolution of the index due to their position early in the value chain. All models are estimated in level terms, and all BVARs are estimated using the same priors.

Forecasting horizon (months)	Oil	Aluminium	Steel	Oil, aluminium and steel
1	0.93	0.90**	0.91**	0.88***
2	0.90	0.85**	0.86*	0.83**
3	0.90	0.83**	0.85	0.82*
4	0.91	0.84	0.86	0.83
5	0.91	0.84	0.87	0.84
6	0.92	0.85	0.87	0.85
12	0.96	0.91	0.91	0.90
24	0.90	0.89	0.87	0.89
36	0.87	0.87	0.86	0.89

Table 1: Relative root mean square error (RMSE) of forecasting models. A score below 1 indicates that RMSE of forecasting model is lower than benchmark. Diebold-Mariano test conducted to test significance of relative performance; ***, **, * indicate 1, 5, 10 percent significance

Table 1 shows the RMSE scores of the different models relative to the RMSE of the benchmark at different forecasting horizons. A value below 1 indicates that the RMSE of the model is *lower* than the RMSE of the benchmark. That is, a value lower than 1 indicates relatively better forecasting

[4]Notice that the results are displayed for total CPI-ATE, not for domestic CPI-ATE. This is done by weighting the contribution using domestic CPI-ATE's weight of total CPI-ATE. Results are also smoothed by showing quarterly, rather than monthly figures.

performance. In general, the commodity price models perform somewhat better than the benchmark model. In the short run, most of the models have significantly better forecasting performance than the benchmark, as tested by the Diebold-Mariano test. More than 3 months ahead, the difference in forecasting performance is not statistically significant.

There is little differentiation of the forecasting performance across the different combinations of commodity prices. The model utilising all three raw material prices performs somewhat better during the first 12 months, whereas the models including only a single raw material perform somewhat better 24 and 36 months ahead. However, the differentiation is small and not statistically significant. This implies that the forecasting properties of the different models varies little across the models, and forecasting performance is expected to be broadly in line across the models.

We choose to primarily use the model utilising all three commodity prices. This provides a broader basis for monitoring the raw materials conceivably provides leading information about the IPI. Additionally, we also condition on futures prices for the commodities when constructing the forecasts. This is in line with the way commodity prices are accounted for in the rest of Norges Bank's analysis apparatus.

5 Concluding remarks

This Staff Memo has introduced Norges Bank's indicator for international price impulses to imported intermediate goods (IPI). The indicator is designed to capture global price impulses that impact the production costs faced by domestic producers in Norway. The IPI is formulated from weighted averages of a diverse set of producer price indices, designed to reflect the import basket utilised by domestic producers. Our empirical evidence suggest that the IPI can account for parts of the inflation surge in the 2022-2023 period. We believe that this finding also supports following the IPI going forward, in order to better monitor price impulses from abroad that could impact domestic price inflation. We will continue to follow the movements in IPI and use it actively in our forecasting processes. We will also continue to develop models to further explore how to use the information in IPI to better understand and forecast developments in consumer price inflation.

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A Appendix

Table 2, 3, 4 and 5 summarize the construction of the index. The aggregate IPI consists of five sub-indices, which in turn consists of a set of product groups. PPIs are collected from Norway's 5 biggest trading partners for each defined product groups.

Table 2: Structure of index I

	IPI	A: Transportation	
Decides weights for IPI categories	Classification of external trade in goods, by groups of end use. Broad Economic Categories (BEC).	1.1: Means of transport, excluding passenger motor vehicles	
	Classification of external trade in goods by levels of processing. Standard International Trade Classification (SITC)	7: Machinery and transport equipment	
Decides which country PPIs are of interest and their weights	Classification of external trade in goods by levels of processing. Standard International Trade Classification (SITC) 2 . Digit level	78: Road vehicles	79: Other transport equipment
Classification corresponding to PPI series	Classification of economic activities. Nomenclature of economic activities (NACE)	C29: Manufacture of motor vehicles, trailers and semi-trailers	C30: Manufacture of other transport equipment
Classification corresponding to PPI series	North American Industry Classification System (NAICS)	336: Transportation equipment manufacturing	
Alternative price series if not using PPI			
Countries included		Germany, Sweden, USA (from 2003),China (from 2013) and Japan	USA (from 2003), South Korea, Turkey (from 2010), UK and Poland

Table 3: Structure of index II

B: Investment goods							C: Food
1.2: Other goods for fixed capital formation, excluding ships and oil platforms		2.2: Parts for machinery and transport equipment					2.1:Food
7: Machinery and transport equipment							
75: Office machines, data processing machines	76: Telecommunications apparatus and equipment	71: Power generating machinery and equipment	72: Machinery for special industries	73: Metal working machinery	74: General industrial machinery and equipment	77: Electrical machinery and apparatus	
C26: Manufacture of computer, electronic and optical products		C28: Manufacture of machinery and equipment n.e.c				C27: Manufacture of electrical equipment	
334: Computer and Electronic Product Manufacturing		333: Machinery manufacturing				3353: Electrical equipment manufacturing	
China (from 2011), Taiwan, USA (2003), Poland, Germany		Germany, Sweden, USA (from 2003), UK and Denmark				China (from 2011), Germany, Sweden, USA (from 2003) and Poland	

[5]

[5] For certain categories we use a slightly different sub-set of countries than top five, this is the case for SITC 62 where we exclude Russia and include 6th ranked country France instead and SITC 67 where Finland is included rather than Russia. The exclusion of Russia relates to the trade sanctions imposed on the country following its invasion of Ukraine in 2022. These sanctions have led to a marked drop in imports from Russia. We also deviate from the top five ranking in the case of SITC 75, as the second most important exporter, Vietnam only provides producer price data at an annual frequency. In its place we include the 6th ranked country Taiwan. The share of imports in the two countries for this category are quite similar (3.9 versus 3.0 percent).

Table 4: Structure of index III

D: Intermediate goods including minerals, chemicals and metals									
2.3: Other intermediate consumption									
2: Crude Materials, inedible except fuels			5: Chemicals and related products n.e.c	6: Manufactured goods classified chiefly by material					
24: Wood, Lumber and Cork	27: Crude fertilisers and crude minerals (from 2002)	28: Metalliferous ores and metal scrap		61: Leather, leather manufactures, furskins	62: Rubber manufactures, n.e.c	63: Cork and wood manufactures	64: Paper, paperboard and manufactures thereof	65: Textile yarn, fabrics, made-up articles	66: Non-metallic mineral manufactures, n.e.c
C16: Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials			C20: Manufacture of chemicals and chemical products	C15: manufacture of leather and related products	C22: Manufacture of rubber and plastic products	C16: Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	C17: Manufacture of paper and paper products	C13: Manufacture of textiles	C23: Manufacture of other non-metallic mineral products
321: Wood product manufacturing			325: Chemical manufacturing	316: Leather and allied product manufacturing	326: Plastics and rubber products manufacturing	321: Wood product manufacturing	322: Paper manufacturing	313: Textile Mills	327: Non-metallic mineral product manufacturing
	Urea Ammonium Nitrate (UAN) (30pct North) Rouen Free on Trucks France Index Euros Per Metric Tonne (from 2008) and DAP, New Orleans CFR Barge	Standard and Poors Goldman Sachs Commodity Index(GSCI) Industrial Metals Spot							
Sweden, Poland, Germany, Estonia (from 2002) and Lithuania			Germany, USA, Sweden, Netherlands and France	China, Italy, Brasil (from 2009), Sweden and India (from 2012)	Germany, China (from 2013), Finland, Sweden and France (from 2005)	Sweden, Poland, Germany, Estonia (from 2002) and Lithuania	Sweden, Germany, Finland, Denmark and the Netherlands	China (from 2011), India (from 2012), Sweden, Germany and Denmark	Sweden, China (from 2011), Germany, Poland and Denmark

Table 5: Structure of index IV

D: Intermediate goods including minerals, chemicals and metals			E: Energy	
3: Building and construction articles			4: Energy products	
6: Manufactured goods classified chiefly by material			3: Mineral fuels, lubricants and related materials	
67: Iron and Steel	68: Non-ferrous metals	69: Manufactures of metals, n.e.c	33: Petroleum, petroleum products	35: Electric current
C24: Manufacture of basic metals		C25: Manufacture of fabricated metal products, except machinery and equipment		
331: Primary Metal Manufacturing		332: Fabricated Metal Product Manufacturing		
			BFO Dated FOB North-sea Crude	Nordpool-Electricity Avg Reference
Sweden, Germany, Japan, UK and Finland		South Korea, Sweden, China (from 2011), Germany and Poland		