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# The role of import prices in flattening the Phillips curve: Evidence from Korea<sup>☆</sup>

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## ABSTRACT

Are global inflation synchronization and the flattening of the Phillips curve across the globe related? The globalization hypothesis has been proposed to explain the relationship but questions remain on its quantitative role. Focusing on South Korea, one of Asia-Pacific supply chain hubs, this paper investigates the extent to which import prices affect domestic price inflation over the period between 2002 and 2020. Specifically, we conduct the regression decomposition method to identify major sources of variation in domestic inflation, followed by a subsequent set of comparative analyses across various inflation forecasting models. Our findings confirm a tight link from import prices to domestic prices, with a 10pp increase in IPI inflation passed onto PPI and CPI inflation by 3.9pp and 3.4pp over time, respectively. The main finding of this study is consistent with the recent global inflation surge that has been driven largely by imported food and energy price channels.

## 1. Introduction

Inflation has been increasingly synchronized globally in the recent decades (e.g., Ha, Kose, & Ohnsorge, 2019; Forbes, 2019). At the same time, it has been widely reported that the Phillips curve has noticeably become flatter across countries over the same period (e.g., Kuttner & Robinson, 2010; IMF, 2013; Gilchrist & Zakrajsek, 2019). Among many competing explanations, one overarching hypothesis emphasizes the role of the goods market globalization partly fueled by the development in global value chains over the past few decades (e.g., Auer, Borio, & Filardo, 2017).

In a nutshell, international production fragmentation and resulting trade in intermediate goods greatly increased import contents of domestic production. Moreover, higher competition in the domestic market due to imported goods tends to exert pressure on firm-level markup adjustments. As a result, the sensitivity of domestic prices to import price fluctuations rises while that to local cost fluctuations declines leading to a flattened Phillips curve. As long as import price fluctuations largely reflect global economic slack and commodity price swings, it also drives global inflation synchronization. This is the extent to which the globalization hypothesis explains current global inflation dynamics.

Noting that the globalization hypothesis implies a prominent transmission channel of import prices to producer prices and hence

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ultimately to consumer prices, this paper empirically investigates the role of import prices in determining domestic price inflation in Korea by applying a set of various methodologies—ranging from a descriptive regression decomposition approach to the simple Phillips curve and error correction model-based inflation forecasting estimation approaches.

Specifically, we identify and quantify the key sources of fluctuations in aggregate consumer price index (CPI), producer price index (PPI), and import price index (IPI) inflation in Korea by conducting the regression decomposition method. First, we find that aggregate CPI inflation is almost exclusively driven by goods CPI inflation, thereby suggesting the importance of considering PPI inflation dynamics. Second, PPI inflation fluctuations are found to be largely determined by fluctuations of PPI inflation in the manufacturing sectors with the highest import contents, which points to a potential link from import prices to domestic prices. Lastly, it turns out that IPI inflation in local currency is mostly affected by IPI inflation in foreign currency rather than by exchange rate fluctuations. This confirms the role of global factors in determining domestic inflation dynamics.

Based on these observations, we empirically evaluate the role of import prices on PPI and CPI inflation dynamics by performing a set of comparative analyses across various inflation forecasting models. Consistent with previous findings in the literature, standard Phillips curve estimation results provide evidence supporting an important role of import prices and the irrelevance of domestic economic conditions in determining domestic PPI and CPI inflation in Korea. Moreover, our error correction model (ECM) estimation results show that a simple inflation forecasting model which explicitly incorporates import prices can be superior to a standard Phillips curve model in forecasting inflation dynamics. This further highlights the role of import prices.

Our exercise also identifies that the main channel through which import prices affect domestic price inflation in Korea is via the IPI-PPI nexus, namely the intermediate inputs channel, which is consistent with the global value chain mechanism within the globalization hypothesis (e.g., Ahn, Park, Park, 2017; Auer & Mehrotra, 2014; Auer, Levchenko, & Sauré, 2019).

Our findings in this paper deliver important implications regarding the (in) effectiveness of central banks monetary policy in managing inflation dynamics. To the extent that import prices are largely determined by exogenous external factors, a dominant role of import prices in determining domestic inflation dynamics suggests that the effect of domestic monetary policy on controlling domestic inflation in a small open economy in the era of goods market hyper-globalization could be much more limited than previously thought.<sup>1</sup> Going forward, it also suggests that the current rise in inflation around the globe after the Covid19- pandemic, which has been largely driven by imported food and energy price channels, is unlikely to be contained by domestic monetary policy alone.

This paper belongs to the literature that studies how commodity price shocks influence underlying effects of monetary policy on inflation. Mallick and Sousa (2013) assessed the monetary policy transmission as well as the impact of fluctuations in commodity prices on the real economy in BRICS countries (i.e., Brazil, Russia, India, China and South Africa). Holtemöller and Mallick (2016) estimated the extent to which the global commodity price movements affect Indian economy. Kumar and Dash (2020) investigated the time-varying effects of monetary policy on aggregate, sectoral, and disaggregate-level inflation and confirmed the presence of a cost channel in the Indian economy in that the commodities prices of some sectors respond positively after a monetary contraction.

The main question of the paper—quantifying the role of import prices in domestic inflation—itself is not new. For example, Jongwanich and Park (2009) conduct the variance decomposition analysis from a VAR estimation and find that external price shocks played a minor role in explaining inflation in Asian emerging market countries over the period between 1996 and 2009. Our findings based on micro-level data from Korea is not necessarily inconsistent with theirs in that Jongwanich and Park (2009) report that the role of import prices in domestic inflation is found to be particularly stronger in Korea.

A recent global inflation surge has drawn attention to the topic again. Carrière-Swallow, Deb, Furceri, Jiménez, and Ostry (2023) find a sizable impact of global shipping costs on domestic prices—from import prices to producer and consumer prices—for 46 advanced and emerging market economies, which is also confirmed with micro-level data for the U.S. (Isaacson & Rubinton, 2022).

This paper is also closely related to the recent literature that tries to explain the observed pattern of flattened Phillips curves across countries. The globalization hypothesis supported by the current study is also backed by Eickmeier and Pijnenburg (2013) who found that global variables greatly improve the inflation forecast model fit for 24 OECD countries; Kabukçuoğlu and Martínez-García (2018) show that the open economy New Keynesian model outperforms the closed economy version in inflation forecasting for 14 advanced countries; Gilchrist and Zakrajsek (2019) and Forbes (2019) directly compare the standard Phillips curve estimation results with and without import prices or with trade exposure measures. Kohlscheen and Moessner (2022) find supporting evidence from a panel of 35 countries that the advance of globalization has been a key force behind the flattening of price Phillips curves.<sup>2</sup>

An alternative hypothesis attributes the flattening of the Phillips curve to the central bank's aggressive monetary policy toward inflation (e.g., Carlstrom, Timothy, & Paustian, 2009 among others), and hence to the resulting well-anchored inflation expectation (e.g., IMF, 2013; Matheson and Stavrev, 2013), to the missing role of household expectations (Coibion & Gorodnichenko, 2015) or simply to statistical artifact (McLeay & Tenreyro, 2019). Since each of them implies fundamentally different policy implication from the globalization hypothesis, it thus highlights the importance of identifying a key factor behind the flattened Phillips curve.

The remainder of the paper is organized as follows. Section 2 introduces the conceptual background and the dataset used in the study. Sections 3, 4, and 5 document sources of inflation dynamics using the accounting regression approach and estimate various sets of inflation forecasting models for IPI, PPI and CPI, respectively. Section 6 draws a conclusion.

<sup>1</sup> This echoes the recent arguments on the dilemma (as opposed to a trilemma) of an international monetary system whereby a small open economy even with the flexible exchange rate scheme cannot implement independent monetary policy without compromising domestic financial stability in a world with financial market hyper-globalization (Rey, 2018; Rajan, 2019).

<sup>2</sup> In the context of domestic inflation in Korea, Kim (2012), Kim and Ro (2019) also found an important role of global factors; Joo and Kang (2014) further suggest that a small open economy like Korea should take into account external factors in setting the optional inflation target rate.

## 2. Conceptual background and data

### 2.1. Conceptual background

Fig. 1 illustrates the whole process of the import price pass-through to domestic prices. For small open economy countries, imports tend to be invoiced rather in foreign currency than in local currency (e.g., Gopinath, Boz, Casas, Díez, Gourinchas & Plagborg-Møller, 2020). Korea is not an exception in that only around 5% of total imports are invoiced in local currency (KRW) as shown in Fig. 2. Once external factors such as foreign exporters' pricing decisions as well as global commodity prices determine import prices in foreign currency, exchange rates will further exert influence as import prices in foreign currencies are converted to those in local ones which may either amplify or condense initial external shocks.

Import prices converted in local currency will then be transmitted to domestic prices either via an imported intermediate goods channel affecting producer prices first and then consumer prices indirectly or via an imported final goods channel affecting consumer prices directly. Considering that the composition of imports in Korea is such that consumption goods account for only around 15% of total imports while the remaining 85% or so is explained by raw materials and capital goods as shown in Fig. 3, we may expect that the effect of import prices on domestic producer prices would be particularly pronounced. Although it is conceptually clear how import prices would affect domestic prices, to what extent these effects could matter for domestic inflation is a totally different question. In order to answer this question, we will begin by performing the accounting regression approach to quantify the sources of time-series variation in the respective price inflation, the results of which will naturally guide us on subsequent inflation forecasting model estimation exercises.

### 2.2. Data

This paper explores three different price indices—IPI, PPI, and CPI—provided at both aggregate and disaggregate levels by the Bank of Korea Economic Statistics System (<https://ecos.bok.or.kr/>).

Specifically, we consider the CPI series from 1990 for the breakdown into goods and service CPI. However, a further breakdown of the goods CPI is only feasible from 2011 since the utility goods series in CPI was first introduced in 2010. Likewise, the sample period for the PPI series starts from 1997 because the service sector PPI was first introduced in 1996, whereas the IPI series is fully available since 1990.

The sample period for inflation forecasting models is commonly set to start from 2002 because the consumer's inflation expectation survey that is essential for the Phillips curve estimation model is only available since then. Table 1 summarizes the weighting schemes of the respective price indices as of 2020.

## 3. Import price index

### 3.1. Accounting for sources of variation in IPI inflation

By construction, the import price in local currency (KRW) is converted from the import price in contract currency by applying the corresponding exchange rates, leading to the following relationship:

$$\Delta \ln IPI_t^{KRW} = \Delta \ln \overline{ER}_t^{KRW/Cont} + \Delta \ln IPI_t^{Cont}, \tag{1}$$

where  $\Delta \ln IPI_t^{KRW}$  and  $+\Delta \ln IPI_t^{Cont}$  is import price inflation rate (defined as the log difference) in KRW and that in contract currency, respectively, while  $\Delta \ln \overline{ER}_t^{KRW/Cont}$  is growth rate in exchange rate between KRW and contract currency.

Given that the import price index is provided separately in local currency (KRW) and contract currency terms, we can evaluate the respective roles of foreign prices and exchange rates in determining fluctuations in import prices in local currency. Raw timeseries data indicates that IPI inflation in contract currency matches IPI inflation in KRW in most periods except for the period of the Asian financial crisis (1997–1998) and the global financial crisis (2008–2009) during which the exchange rate was extremely volatile (Fig. 4a).

To quantify the extent to which IPI inflation in contract currency and exchange rates can explain variation in IPI inflation in local

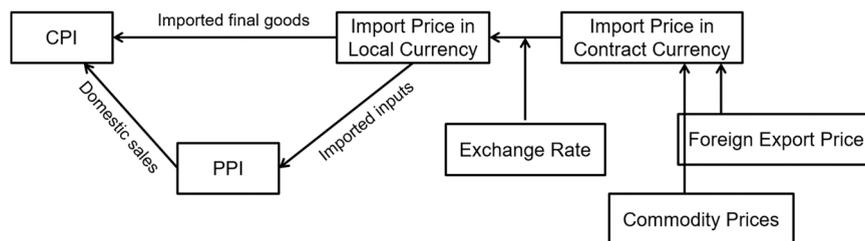
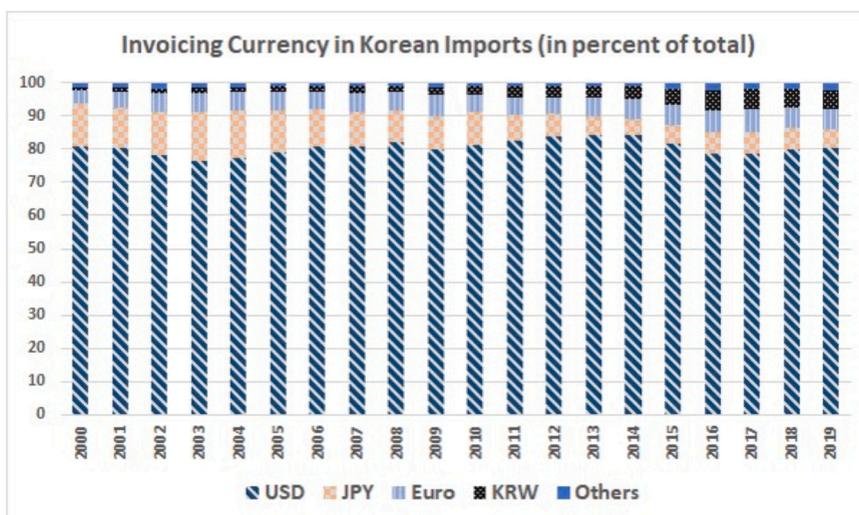
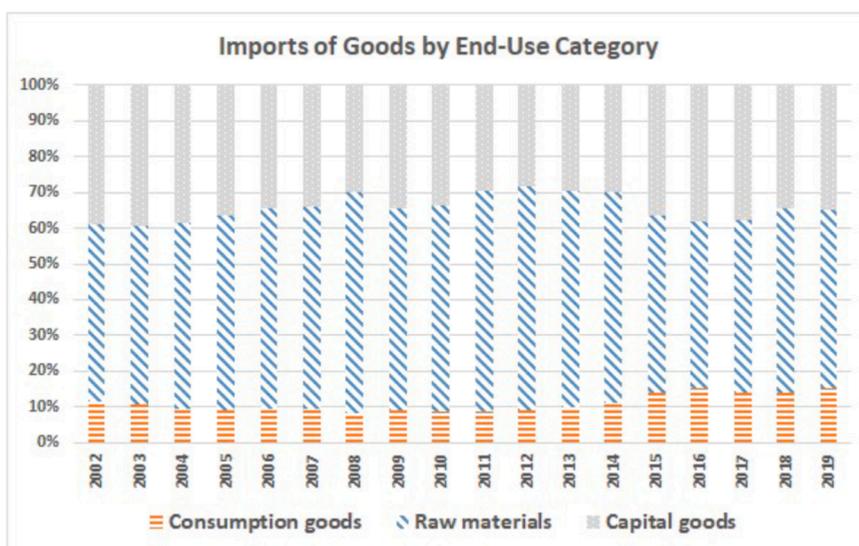


Fig. 1. A Schematic Diagram of the Transmission of External Prices. Note: This figure illustrates various channels through which external prices are transmitted to domestic producer and consumer prices.



**Fig. 2.** The Pattern of Currency Invoicing in Imports. Note: This figure shows the composition of invoicing currency in Korean imports over the period between 2000 and 2019.

Source: the Bank of Korea Economic Statistics System.



**Fig. 3.** Composition of Imported Goods by End-use Category. Note: This figure shows the composition of Korean imports by end-use category over the period between 2002 and 2019.

Source: Korea Customs Service Trade Statistics.

**Table 1**

Weighting Schemes in Price Indices (as of 2020).

| CPI weight         | PPI weight | PPI weight                      | IPI weight |
|--------------------|------------|---------------------------------|------------|
| Goods              | 448.5      | Goods                           | 601.9      |
| Agricultural goods | 77.1       | Agricultural goods              | 35.7       |
| Industrial goods   | 333.1      | Mining/Quarrying goods          | 2.6        |
| Utility goods      | 38.3       | Industrial goods                | 503.4      |
| Service            | 551.5      | Utility goods                   | 60.2       |
|                    |            | Industrial goods                | 503.4      |
|                    |            | Petroleum/Coal                  | 32.9       |
|                    |            | Chemical                        | 85.9       |
|                    |            | Metal                           | 51.5       |
|                    |            | Others                          | 333.1      |
|                    |            | Agricultural goods              | 38.6       |
|                    |            | Mining/Quarrying goods          | 262.5      |
|                    |            | Industrial goods                | 698.9      |
|                    |            | Petroleum/Coal, Chemical, Metal | 249.3      |
|                    |            | Others                          | 449.6      |

Note: This table summarizes the weighting schemes in consumer, producer, and import price indices as of 2020. Source: the Bank of Korea Economic Statistics System.

currency, we run the following accounting regressions:

$$\Delta \ln IPI_t^{Cont} = \alpha_1 + \beta_1 \Delta \ln IPI_t^{KRW}, \tag{2}$$

$$\Delta \ln \overline{ER}_t^{KRW/Cont} = \alpha_2 + \beta_2 \Delta \ln IPI_t^{KRW}, \tag{3}$$

which are known as the regression decomposition method *a la* Bernard, Jensen, Redding, and Schott (2009). The coefficients for each set of regressions should sum up to one (that is,  $\beta_1 + \beta_2 = 1$  and  $\alpha_1 + \alpha_2 = 0$ ) with each coefficient  $\beta_1$  and  $\beta_2$  representing the share of the overall variation in IPI inflation explained by IPI inflation in contract currency and growth in exchange rates, respectively.

Specifically, we run monthly frequency versions of the accounting regression above on a rolling basis with 24 months windows, the results of which are summarized in Fig. 4b where the estimated time-varying coefficients from the accounting regression of Eqs. (2) and (3) are stacked. This confirms a dominant role of foreign prices on domestic import prices compared to fluctuations in exchange rates, which is particularly pronounced in the recent period.

We further decompose the source of variation in aggregate IPI inflation in contract currency into agriculture, mining/quarrying, and industrial goods IPI inflation. Raw timeseries data illustrate the highly volatile nature of import prices. Import prices in mining/quarrying sector goods are the most volatile although less volatile industrial goods' import prices tend to move in tandem. On the other hand, agriculture goods' import prices with a weight in IPI of just around 3.9% (38.9/1000 in Table 1) often deviate from other import prices implying a minor role in determining aggregate IPI inflation (Fig. 4c).

Since the aggregate import price index is the weighted geometric average of the lower-level import price indices, it is defined as:

$$IPI = \prod_i^N (IPI_i)^{w_i} \tag{4}$$

where  $IPI_i$  is  $i$ 's component import price index with the weight  $0 < w_i < 1$ . It then follows that aggregate import price inflation is expressed as the weighted sum of the lower-level price inflation:

$$\pi_i^{IPI} = \Delta \ln IPI_t = \sum_i^N w_i \Delta \ln IPI_{it} = \sum_i^N w_i \pi_{it}^{IPI} \tag{5}$$

where the IPI inflation rate is defined as the log difference of IPI over the period.<sup>3</sup> This highlights the simple fact that a component with a greater weight or a more volatile component can affect fluctuations in aggregate IPI inflation more significantly. At the same time, this also implies that a component with a high weight may not contribute much to aggregate IPI inflation fluctuations if its inflation is rather stable and vice versa. This stresses the fact that we should consider both weights and variations together in order to gauge an overall contribution of each component to aggregate IPI inflation fluctuations.

Noting that the above expression is nothing but an accounting identity, we can run a set of the following accounting regressions for all  $i$  components as done above in Eqs. (2) and (3):

$$w_i \pi_{it}^{IPI} = \alpha_i + \beta_i \pi_{it}^{IPI}, \tag{6}$$

and estimate coefficients for all  $i \in \{Agriculture, Mining/Quarrying, Industrial\}$ . The coefficients for each set of regressions should sum up to one (that is  $\sum_i^N \beta_i = 1$  and  $\sum_i^N \alpha_i = 0$ ) with each coefficient,  $\beta_i$ , representing the share of the overall variation in aggregate IPI inflation explained by  $i$  component, taking into account the respective weight.

According to the estimation results illustrated in Fig. 4d that stacks the estimated time-varying coefficients from the accounting regression of Eq. (6) for three different sectors, import prices in mining / quarrying and industrial sector goods account for almost all of the aggregate IPI inflation fluctuations with an increasing role of the former in the recent period.<sup>4</sup>

Overall, our findings above confirm that external factors (as opposed to exchange rates) embodied in import prices in foreign currency are major sources of variation in import prices in local currency. Moreover, we note that imported mining/quarrying and industrial goods that are more likely to be used as intermediate inputs for domestic production turned out to be particularly relevant for the variation in aggregate IPI inflation. This suggests that IPI inflation could potentially be a major source of PPI inflation fluctuations which in turn could partly explain variation in CPI inflation.

**Fact 1.** Aggregate IPI inflation in KRW is mostly driven by aggregate IPI inflation in contract currency as opposed to the KRW/contract currency exchange rate. Aggregate IPI inflation in contract currency is in turn mainly driven by mining/quarrying and industrial goods IPI inflation.

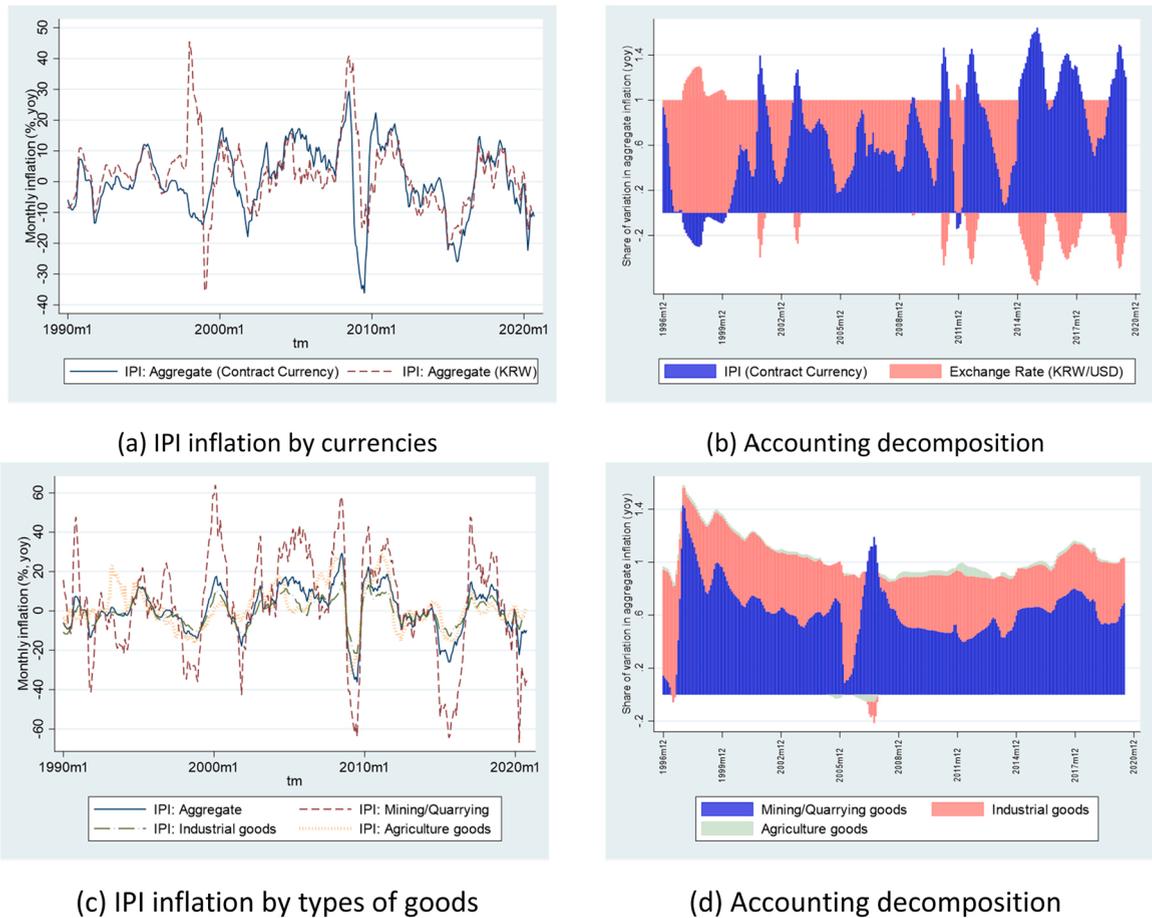
### 3.2. IPI inflation forecasting models

Given the potential importance of import prices on domestic PPI inflation dynamics (and hence, on CPI inflation dynamics), this section offers an IPI inflation forecasting model by investigating potential determinants of IPI inflation dynamics.

We begin by noting that import prices in a small open economy like Korea will be determined almost completely by external factors.

<sup>3</sup> The second equality may not hold exactly if weights change during the period.

<sup>4</sup> Note that the sum of the estimated coefficients is not exactly equal to 1 in earlier periods because the weights are based on latest periods.



**Fig. 4.** Monthly IPI Inflation: Time-series Evolution and Accounting Decomposition. Note: These figures show the evolution of the monthly aggregate import price inflation in local currency (KRW) and that in contract currency (panel (a)) and the regression decomposition result from the specifications expressed in Eqs. (2) and (3) (panel (b)); the evolution of the monthly import price inflation in contract currency by type of goods (panel (c)) and the regression decomposition result from the specification expressed in Eq. (6) (panel (d)). Although the sum of the estimated coefficients should be equal to 1, it may not be exactly equal to 1 in some periods because the weights are not perfectly updated.

Our earlier findings in Fig. 4d that IPI inflation dynamics are mostly driven by mining and quarrying sectors as well as industrial sector’s import prices suggest that major trading partners’ export prices and commodity prices are likely the main sources. As such, we consider the following ECM model:

$$\Delta \ln IPI_t^{cont} = c + \alpha (\ln IPI_{t-1}^{cont} - \beta_1 \ln \overline{EPI}_{t-1} - \beta_2 \ln Fuel_{t-1}) + \gamma_1 \Delta \ln \overline{EPI}_{t-1} + \gamma_2 \Delta \ln Fuel_{t-1} + \varepsilon_t, \tag{7}$$

where the dependent variable is the IPI inflation rate in the contract currency term, while  $\Delta \ln Fuel_{t-1}$  and  $\Delta \ln \overline{EPI}_{t-1}$  is the crude oil price inflation rate and the average export price inflation rate among major trading partner countries, respectively, both of which are taken from the IMF database.<sup>5</sup>

Table 2 summarizes estimation results from ECMs with average EPI inflation of major trading partners and/or global oil price inflation. The estimated error correction coefficients are all negative and statistically significant across columns supporting the presence of co-integration relationship among IPI and average export prices of major trading partner countries and global oil prices.

Including major trading partner countries’ average export prices alone yields more than a one-to-one response of IPI inflation to a change in foreign export price inflation (column 1). A 10pp increase in foreign export price inflation leads to a 17pp increase in IPI inflation in the short run and a 13pp increase in IPI inflation in the long run. A bigger coefficient estimate on the short-run coefficient than on the long-run coefficient indicates a possible overshooting effect.

Replacing foreign export prices by global oil prices also returns positive and statistically significant estimates for both short-run and long-run coefficients: a 10pp increase in global oil price inflation leads to a 3pp increase in IPI inflation in the short run and 4.8pp

<sup>5</sup> Major trading partner countries are Japan, EU, and the U.S. China is not included due to data availability issues.

**Table 2**  
ECM Estimation Results: IPI Inflation.

|                         | (1)<br>IPI:ECM1       | (2)<br>IPI:ECM2        | (3)<br>IPI:ECM3        |
|-------------------------|-----------------------|------------------------|------------------------|
| Short-run               |                       |                        |                        |
| $\Delta \ln(EPI)_{it}$  | 1.737 * **<br>(0.229) |                        | 0.670 * **<br>(0.115)  |
| $\Delta \ln(Fuel)_{it}$ |                       | 0.306 * **<br>(0.016)  | 0.285 * **<br>(0.016)  |
| Constant                | -0.113<br>(0.176)     | 0.550 * **<br>(0.156)  | 0.375 * **<br>(0.128)  |
| Long-run                |                       |                        |                        |
| $\ln(EPI)_{it-1}$       | 1.279 * **<br>(0.366) |                        | 0.154<br>(0.144)       |
| $\ln(Fuel)_{it-1}$      |                       | 0.477 * **<br>(0.026)  | 0.462 * **<br>(0.050)  |
| Error Correction coeff  | -0.093 *<br>(0.055)   | -0.237 * **<br>(0.068) | -0.225 * **<br>(0.069) |
| OBS                     | 72                    | 74                     | 72                     |

Note: This table summarizes IPI inflation forecasting model estimation results based on the error correction model (ECM) approach, specified in 7. Column (1) includes major trading partners' average export prices only, column (2) includes global brent oil price only, and column (3) includes both. Robust standard errors are in parentheses. \*: significant at 10% level; \*\*: significant at 5% level; \*\*\*: significant at 1% level.

increase in IPI inflation over time with a relatively fast adjustment process as indicated in the error correction coefficient estimate (column 2).

Once both foreign export prices and global oil prices are included, the estimated coefficient on foreign export prices in column 3 drops substantially for both short-run and long-run coefficients while the short-run coefficient remains statistically significant. On the other hand, the coefficients for oil prices hardly change which suggests that the estimated coefficients of foreign export prices in column 1 likely suffered from the omitted variable bias due to the exclusion of oil prices. Overall, the estimated coefficients imply that a 10pp increase in foreign export prices and oil prices leads to a 6.7pp and 2.9pp increase in IPI inflation in the short run, respectively. In the long run, a 10pp increase in oil prices affects IPI inflation by 4.6pp.

Fig. 5a illustrates that an in-sample fit from the ECM estimation with only foreign export prices included yields quite a good fit for IPI inflation dynamics confirming a substantial role of major trading partner countries' export prices. Fig. 5b represents the ECM estimation with both foreign export and oil prices included yielding an improved in-sample fit and thus confirming the relevance of global oil prices in determining IPI inflation. Table 3 summarizes in-sample fits across IPI forecast models based on root mean squared errors (RMSE).

#### 4. Producer price index

##### 4.1. Accounting for sources of variation in PPI inflation

By construction, the aggregate producer price index is the weighted geometric average of the lower-level producer price indices:

$$PPI = \prod_i^N (PPI_i)^{w_i}, \tag{8}$$

where  $PPI_i$  is  $i$ 's component producer price index with the weight  $0 < w_i < 1$ . It then follows that aggregate producer price inflation is expressed as the weighted sum of the lower-level producer price inflation:

$$\pi_i^{PPI} = \Delta \ln PPI_t = \sum_i^N w_i \Delta \ln PPI_{it} = \sum_i^N w_i \pi_{it}^{PPI}, \tag{9}$$

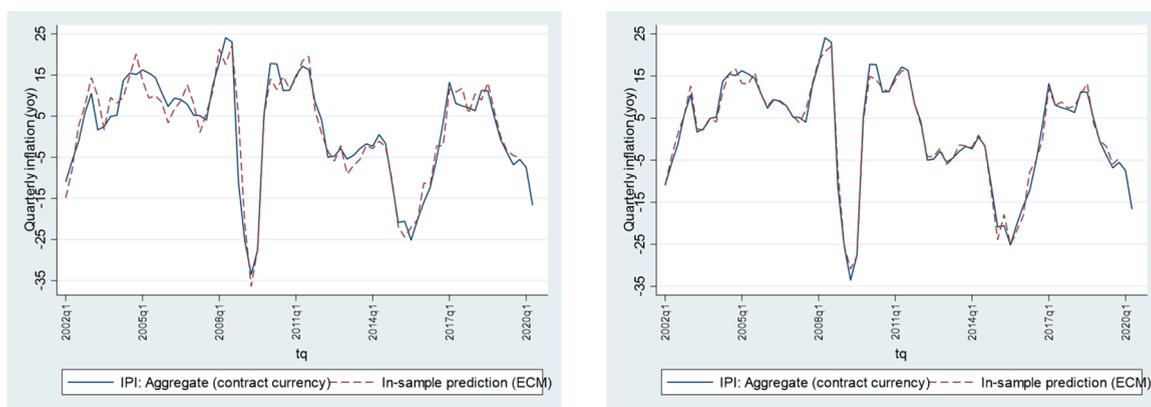
where the inflation rate is defined as the log difference of the respective price index over the period.<sup>6</sup> Similarly to the case of IPI, we can apply the regression decomposition method as:

$$w_i \pi_{it}^{PPI} = \alpha_i + \beta_i \pi_i^{PPI}, \tag{10}$$

where the coefficients for each set of regressions should sum up to one (that is,  $\sum_i^N \beta_i = 1$  and  $\sum_i^N \alpha_i = 0$ ), with each coefficient,  $\beta_i$ , representing the share of the overall variation in PPI inflation explained by  $i$  component, taking into account the respective weight.

To consider the first-tier decomposition of aggregate PPI inflation, we break it down into the goods and service PPI inflation. Table 1 indicates that the goods sector products represent a majority of PPI components with the weight being a little over 60% while service sector products represent the remaining 40%. Raw time-series data show that the service PPI tends to be highly stable throughout the period since 1997 while the goods PPI is much more volatile and matches the aggregate PPI quite closely (Fig. 6a). This

<sup>6</sup> The second equality may not hold exactly if weights change during the period.



(a) ECM with EPI only

(b) ECM with EPI+Fuel

**Fig. 5.** Quarterly IPI Inflation: Actual and Error Correction Model Estimates. Note: These figures illustrate IPI inflation forecasting model estimation results based on the error correction model (ECM) approach, specified in Eq. (7). Panel (a) includes major trading partners’ export price inflation only as an explanatory variable, while panel (b) also includes global fuel price inflation.

**Table 3**  
Comparison of In-Sample Forecast across Estimation Models (IPI).

|                         | ECM1 (EPI) | ECM2 (Fuel) | ECM1 (EPI+Fuel) |
|-------------------------|------------|-------------|-----------------|
| RMSE                    | 3.59       | 2.06        | 1.53            |
| RMSE (relative to ECM1) | 1.00       | 0.57        | 0.43            |

Note: This table summarizes the comparison of in-sample forecast performance across IPI inflation forecast models. ECM1 refers to the ECM model with major trading partners’ average export prices only, ECM2 refers to the ECM model with global brent oil price only, and ECM3 refers to the ECM model with both major trading partners’ average export prices and global brent oil price.

is clearly reflected in the regression decomposition results, suggesting that the goods PPI can explain almost all of the fluctuations in aggregate PPI inflation with its explanatory power close to 100% throughout the period (Fig. 6b).

Taking a closer look into the goods PPI inflation, we further break down the goods PPI inflation into agricultural, industrial, and utility goods PPI inflation. Raw time-series data shows that agricultural PPI inflation is the most volatile while industrial PPI inflation matches goods PPI inflation most closely owing to its high weight of around 84% (503.4/601.9 in Table 1) (Fig. 6c). The regression decomposition analysis confirms that industrial goods PPI inflation alone can explain nearly all of the goods PPI inflation fluctuations (Fig. 6d).

Tracking the main source of variation in industrial goods PPI inflation, we note that inflation of three manufacturing goods’ prices (Petroleum/Coal, Chemical, and Metal) are the most volatile while the chemical goods PPI inflation happens to match the industrial goods PPI inflation particularly well (Fig. 6e). In fact, although those three manufacturing goods account for only around 33% of total weights in the industrial goods PPI (170.3/503.4 in Table 1), they can explain a majority of the industrial goods PPI inflation in the recent periods (Fig. 6f).

In sum, our findings in this section highlight an important role of industrial goods PPI inflation in determining aggregate PPI inflation dynamics. Moreover, considering that three major products in determining industrial goods PPI inflation—Petroleum/Coal, Chemical, and Metal—happen to be some of the highest import contents products (83% for Petroleum; 31% for Chemical, and 28% for Metal according to the 2015 Input-Output Table published by the Bank of Korea), this also points to a potential link from import prices to domestic producer prices.

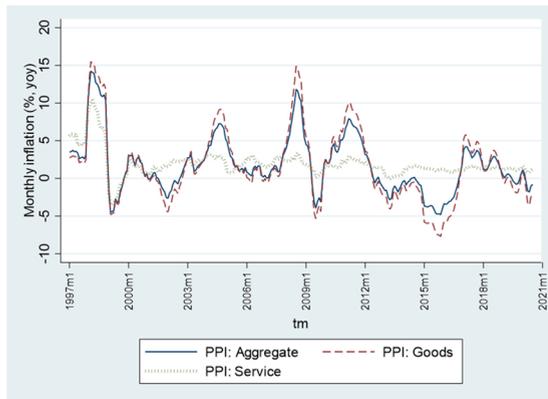
**Fact 2.** Aggregate PPI inflation is almost exclusively driven by goods PPI inflation, which, in turn, is mostly explained by industrial goods PPI inflation such as Petroleum/Chemical/Metal products among others.

#### 4.2. PPI inflation forecasting models

This section performs a simple comparative analysis of several PPI inflation forecasting models. We will first consider a variant of standard Phillips curve models, and then move on to several versions of error correction models (ECM).

Similarly to Gilchrist and Zakrajsek (2019), we apply a variant of the standard Phillips curve model to estimate the aggregate PPI inflation using the quarterly frequency data as in

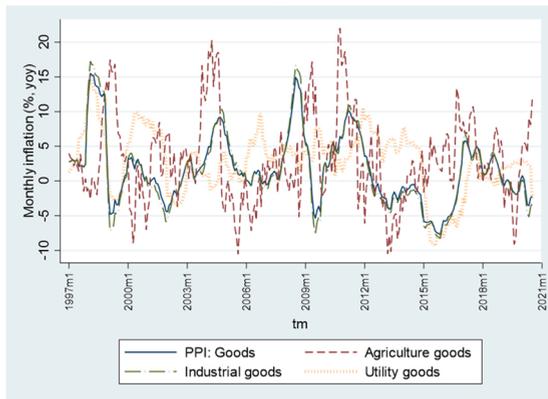
$$\Delta \ln PPI_t = c + \beta \pi_{t+4}^e + \gamma \widehat{GDP}_t + \delta \Delta \ln IPI_t + \varepsilon_t, \tag{11}$$



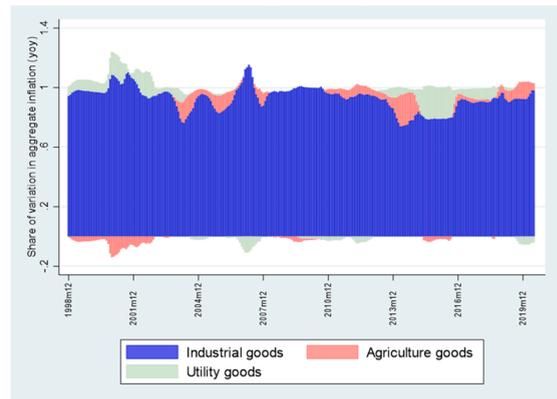
(a) PPI inflation: goods and service



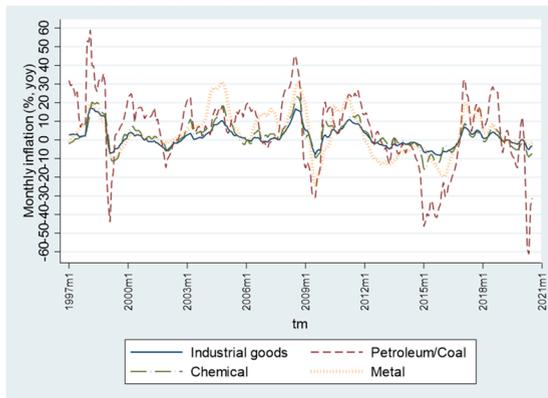
(b) Accounting decomposition



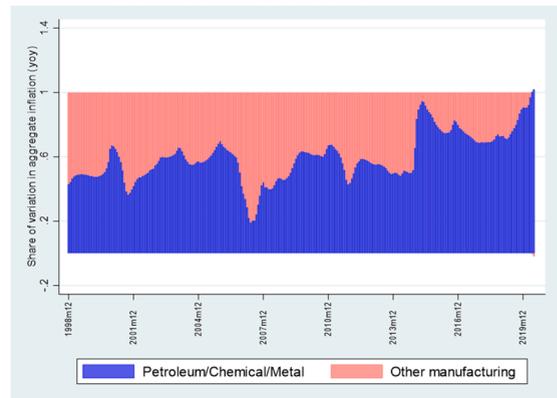
(c) PPI goods inflation by sectors



(d) Accounting decomposition



(e) Industrial PPI inflation by sub-sectors



(f) Accounting decomposition

**Fig. 6.** Monthly PPI Inflation: Time-series Evolution and Accounting Decomposition. Note: These figures show the evolution of the monthly aggregate producer price inflation, broken down by goods and service producer price inflation (panel (a)) and the regression decomposition result from the specification expressed in Eq. (10) (panel (b)); the evolution of the monthly goods producer price inflation, broken down by sector-level producer price inflation (panel (c)) and the regression decomposition result from the specification expressed in Eq. (10) (panel (d)); the evolution of the monthly industrial goods producer price inflation, broken down by sub-sector-level producer price inflation (panel (e)) and the regression decomposition result from the specification expressed in Eq. (10) (panel (f)). Although the sum of the estimated coefficients should be equal to 1, it may not be exactly equal to 1 in some periods because the weights are not perfectly updated.

where  $\pi_{t+4}^e$  is the one-year-ahead CPI inflation expectation from the survey of consumer expectations,  $\widehat{GDP}_t$  is the estimated output gap from the Hodrick-Prescott (HP) filter method and  $\Delta \ln IPI_t$  is the aggregate import price inflation. This is also close to the CPI version estimation model in Chang, Choi, and Park (2016) that we consider later below.

To investigate the role of import prices in determining PPI inflation, we compare the regression results with and without an import price inflation term. Column 1 in Table 4 reports the estimation result for the full sample from 2002 Q1 to 2020 Q2 without an import price inflation term. The results confirm an important role of the inflation expectation and the output gap in determining PPI inflation, thereby supporting the validity of the Phillips curve model for PPI inflation in Korean economy. The magnitudes of the estimated coefficients suggest that a 1pp increase in one-year ahead inflation expectations is associated with an increase in PPI inflation of 1.95pp while a 1pp increase in output gap is associated with an increase in PPI inflation of about 0.55pp.

However, once an import price inflation term is included, the estimated coefficient of the output gap term drops substantially to a negative domain and becomes statistically insignificant whereas the coefficient of the import price inflation term is estimated to be positive and statistically significant (column 2). We also note a significant increase in R-squared values as an import price inflation term is added to the estimation. Such a pattern is more pronounced in the recent period (columns 5 and 6) compared to the earlier period (columns 3 and 4). In particular, once import prices inflation is controlled for, the estimated coefficient on the output gap term becomes negative and statistically significant (column 6), implying that the traditional Phillips curve relationship for PPI inflation totally disappeared lately.<sup>7</sup>

A significant role of import prices in determining PPI inflation but a rather weak relationship between domestic economic conditions and PPI inflation is highlighted in Fig. 7a and b revealing a much more improved fit of PPI inflation dynamics when the augmented Phillips curve model with import prices is considered.

Given the importance of import prices found from the above exercise, we move on to considering alternative models of PPI inflation forecasts, namely error correction models (ECMs) that focus on the short-run as well as potential co-integration relationships between PPI and IPI as below:

$$\Delta \ln PPI_t = c + \alpha (\ln PPI_{t-1} - \beta_1 \ln IPI_{t-1}) + \gamma_1 \Delta \ln IPI_t + \varepsilon_t, \quad (12)$$

where  $\alpha$  is the error correction coefficient that reflects the speed of adjustment towards the long-run relationship while the error correction term representing the long-run relationship is inside the parenthesis. The short-run effect of IPI inflation on PPI inflation can be measured through the estimate of the coefficient,  $\gamma_1$ . Excluding the import price terms— $\beta_1 \ln IPI_{t-1}$  and  $\gamma_1 \Delta \ln IPI_t$ —reduces the formula to the AR(1) model of PPI in log.

Table 5 summarizes the estimation results. The baseline ECM estimation result that explicitly accounts for the effect of IPI inflation confirms the presence of co-integrating relationships as reflected in the negative and statistically significant error correction coefficient estimate (column 2). Moreover, the short-run coefficient estimate of the IPI inflation term suggests that a 10pp increase in IPI inflation is passed onto PPI inflation by 2.5pp in a quarter, and the long-run coefficient estimate reveals that it will eventually lead to an increase in PPI inflation by 4.6pp in the long run.

The baseline ECM specification can be further modified by replacing IPI inflation with external factors such as average EPI inflation of major trading partners and/or global oil price inflation. This could serve as a kind of intermediation tests that more clearly identifies the transmission channel, thereby shedding light on specific channels through which import prices affect PPI inflation (column 3): average EPI inflation of major trading partners as well as global oil price inflation affect PPI inflation strongly in the short run while there is a strong and positive long-run relationship between average EPI inflation of major trading partners and PPI inflation only. In particular, the estimated coefficients suggest that a 10pp increase in major trading partners' EPI inflation is passed onto PPI inflation by 1.8pp in a quarter, while the long-run coefficient estimate reveals that it will eventually lead to an increase in PPI inflation by 7.4pp in the long run. Likewise, while a 10pp increase in global oil price will lead to an increase in PPI inflation by 0.36pp in a quarter.

Fig. 7c illustrates that the in-sample fit from the baseline ECM with aggregate IPI inflation terms appears to be much more improved compared to the estimation fit from the augmented Phillips curve model with IPI inflation shown in Fig. 7b. A modified version of ECM with external factors seems to provide a slightly worse in-sample fit than the baseline ECM with aggregate IPI inflation (Fig. 7d).

Relative performance of respective PPI inflation estimation models is summarized in Table 6 in terms of in-sample root mean squared errors (RMSE). Even though the augmented Phillips curve model (Aug.PC) performs much better than the standard Phillips curve model (PC), its performance is only as good as that of the AR(1) model. However, when incorporating import prices into AR(1) settings the baseline ECM with aggregate IPI inflation terms improves the in-sample fit substantially by 44% (0.67 vs. 1.19). Replacing the aggregate IPI with external factors deteriorates the in-sample fit from the baseline ECM (0.79 vs. 0.67) but still performs better than the augmented Phillips curve model.

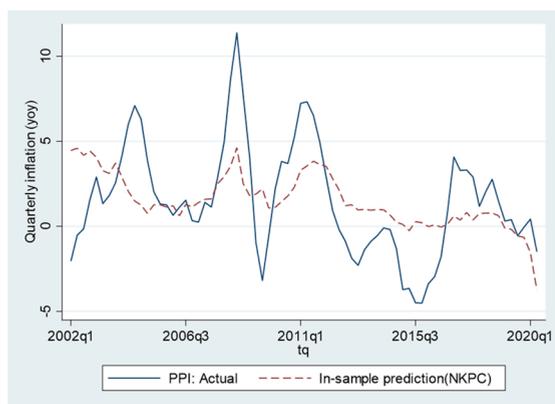
Overall, the augmented Phillips curve model and the ECM estimation results strongly indicate an important role of IPI inflation in the determination of PPI inflation, suggesting the presence of the PPI channel through which IPI inflation is transmitted to domestic CPI inflation.

<sup>7</sup> We also estimated the model using GMM estimator with lagged independent variables as IVs to account for the potential endogeneity issue, and there is no major difference in the results.

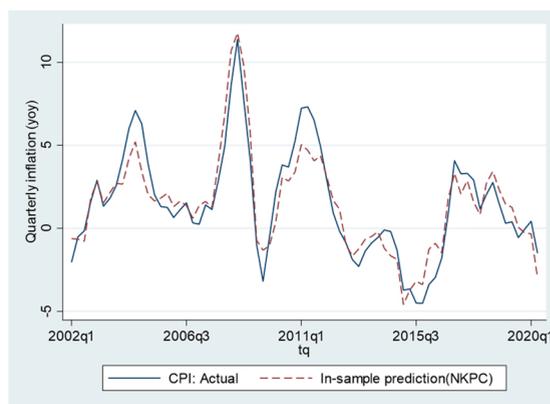
**Table 4**  
Simple Phillips Curve Estimation Results: PPI Inflation.

| Inflation expectation  | (1)<br>2002 Q1-2020 Q2 | (2)       | (3)<br>2002 Q1-2011 Q4 | (4)       | (5)<br>2012 Q1-2020 Q2 | (6)        |
|------------------------|------------------------|-----------|------------------------|-----------|------------------------|------------|
|                        | 1.949 ***              | 0.606 *** | 1.038                  | 0.353     | 0.422                  | 0.369 *    |
|                        | (0.518)                | (0.178)   | (0.964)                | (0.328)   | (0.525)                | (0.204)    |
| GDP gap                | 0.547 *                | -0.043    | 0.331                  | 0.025     | 0.933 *                | -0.401 *** |
|                        | (0.323)                | (0.147)   | (0.423)                | (0.155)   | (0.533)                | (0.127)    |
| Import price inflation |                        | 0.268 *** |                        | 0.258 *** |                        | 0.284 ***  |
|                        |                        | (0.017)   |                        | (0.022)   |                        | (0.024)    |
| Constant               | -4.678 ***             | -0.809    | -0.740                 | 0.325     | -1.358                 | -0.351     |
|                        | (1.532)                | (0.568)   | (3.232)                | (1.200)   | (1.498)                | (0.589)    |
| R-squared              | 0.230                  | 0.863     | 0.0467                 | 0.821     | 0.139                  | 0.843      |
| OBS                    | 74                     | 74        | 40                     | 40        | 34                     | 34         |

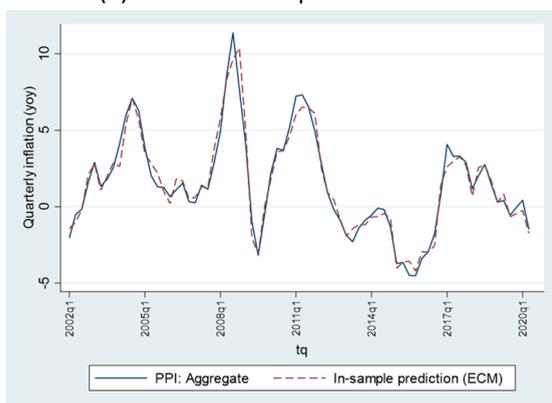
Note: This table summarizes PPI inflation forecasting model estimation results based on the simple Phillips curve model approach, specified in Eq. 11. Columns (1) and (2) includes an entire sample period from 2002 to 2020; Columns (3) and (4) considers an earlier sample period from 2002 to 2011; Columns (5) and (6) covers the latter sample period from 2012 to 2020; Columns (1), (3), and (5) correspond to a standard Phillips curve model without an import price term, whereas columns (2), (4), and (6) are from an augmented Phillips curve model with an import price term. Robust standard errors are in parentheses. \*: significant at 10% level; \*\*: significant at 5% level; \*\*\*: significant at 1% level.



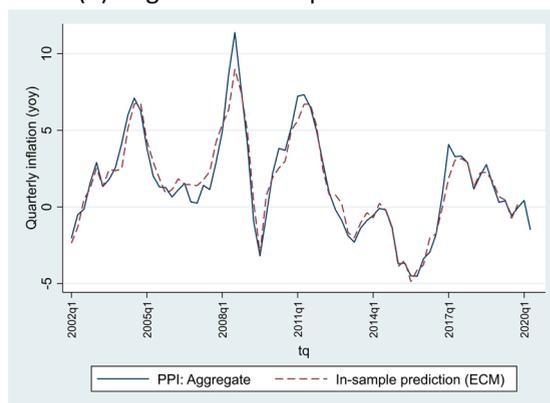
(a) Standard Phillips curve model



(b) Augmented Phillips curve model



(c) ECM with aggregate IPI



(d) ECM with EPI and Fuel prices

**Fig. 7.** Quarterly PPI Inflation: Actual and Model Estimates. Note: These figures illustrate PPI inflation forecasting model estimation results. They compare the actual PPI inflation with the predicted PPI inflation from the standard Phillips curve model, specified in Eq. (11), without an import price term (panel (a)) or with the predicted PPI from the augmented Phillips curve model with an import price term (panel (b)); PPI inflation forecasting model estimation results based on the error correction model (ECM) approach, specified in Eq. (12) (panel (c) and (d)).

**Table 5**  
AR(1) and ECM Estimation Results: PPI Inflation.

|                         | (1)                   | (2)                   | (3)                    |
|-------------------------|-----------------------|-----------------------|------------------------|
| Short-run               | PPI:AR (1)            | PPI:ECM1              | PPI:ECM2               |
| $\Delta \ln(IP)_{it}$   |                       | 0.249 * **<br>(0.021) |                        |
| $\Delta \ln(EPI)_{it}$  |                       |                       | 0.180 * **<br>(0.059)  |
| $\Delta \ln(Fuel)_{it}$ |                       |                       | 0.036 * **<br>(0.009)  |
| Constant                | 0.157 * *<br>(0.063)  | 0.096 * *<br>(0.046)  | 0.198 * **<br>(0.063)  |
| Long-run                |                       |                       |                        |
| $\ln(IP)_{it-1}$        |                       | 0.455 * **<br>(0.109) |                        |
| $\ln(EPI)_{it-1}$       |                       |                       | 0.744 * **<br>(0.103)  |
| $\ln(Fuel)_{it-1}$      |                       |                       | -0.006<br>(0.036)      |
| Error Correction coeff  | -0.034 * *<br>(0.014) | -0.038 * *<br>(0.017) | -0.163 * **<br>(0.044) |
| OBS                     | 74                    | 74                    | 72                     |

Note: This table summarizes PPI inflation forecasting model estimation results based on the error correction model (ECM) approach, specified in Eq. (12). Column (1) does not include any import price term and thus reduces to AR(1) model. Column (2) includes aggregate import price index terms, while column (3) includes major trading partners' average export prices and global brent oil price. Robust standard errors are in parentheses. \*: significant at 10% level; \*\*: significant at 5% level; \*\*\*: significant at 1% level.

**Table 6**  
Comparison of In-Sample Forecast across Estimation Models (PPI).

| RMSE                       | PC   | Aug. PC | AR   | ECM1 (IPI) | ECM2 (EPI+Fuel) |
|----------------------------|------|---------|------|------------|-----------------|
|                            | 5.03 | 1.19    | 1.19 | 0.67       | 0.79            |
| RMSE (relative to Aug. PC) | 4.22 | 1.00    | 1.00 | 0.56       | 0.66            |

Note: This table summarizes the comparison of in-sample forecast performance across PPI inflation forecast models. PC, Aug.PC, AR, and ECM denote standard Phillips curve, augmented Phillips curve, autoregressive, error correction model, respectively. ECM1 refers to the baseline ECM model with aggregate import price index only, and ECM2 refers to the ECM model with both major trading partners' average export prices and global brent oil price.

## 5. Consumer price index

### 5.1. Accounting for sources of variation in CPI inflation

By construction, the aggregate price index is the weighted geometric average of the lower-level price indices:

$$CPI = \prod_i^N (CPI_i)^{w_i}, \tag{13}$$

where  $CPI_i$  is  $i$ 's component price index with the weight  $0 < w_i < 1$ . It follows that the aggregate price inflation is expressed as the weighted sum of the lower-level price inflation:

$$\pi_t^{CPI} = \Delta \ln CPI_t = \sum_i^N w_i \Delta \ln CPI_{it} = \sum_i^N w_i \pi_{it}^{CPI}, \tag{14}$$

where the inflation rate is defined as the log difference of the respective price index over a certain period.<sup>8</sup>

As shown earlier, we can run a set of the following regressions for all  $i$  components:

$$w_i \pi_{it}^{CPI} = \alpha_i + \beta_i \pi_{it}^{CPI}, \tag{15}$$

where the coefficients for each set of regressions should sum up to one (that is,  $\sum_i^N \beta_i = 1$  and  $\sum_i^N \alpha_i = 0$ ) with each coefficient,  $\beta_i$ , representing the share of the overall variation in CPI inflation explained by each component  $i$ 's CPI inflation, taking into account the respective weights.

We begin by considering the first-tier decomposition and by breaking down the aggregate CPI inflation into goods and service CPI inflation. As shown in Table 1, CPI service sector products represent a majority of CPI components with the weight being a little over

<sup>8</sup> The second equality may not hold exactly if weights change during the period.

55%, while the goods sector products represent the remaining 45%. However, raw timeseries data show that service CPI inflation tends to be less volatile especially in the past decade, whereas goods CPI inflation is highly volatile (Fig. 8a). Since aggregate CPI inflation is defined and constructed as a weighted sum of goods and service CPI inflation, aggregate CPI inflation lies in between service and goods CPI inflation rates. Although goods CPI inflation appears to match aggregate CPI inflation more closely, it is not easy to quantify the respective contribution from a glance at raw figures.

Thus, we turn to the regression decomposition analysis which offers a quantitative sense of relative contribution to aggregate CPI inflation fluctuations. It suggests that goods CPI can explain overall fluctuations in aggregate CPI inflation much better than service CPI with its explanatory power ranging from 50% to over 100% in the recent years (Fig. 8b).

Regarding goods CPI inflation, we move on to the second-tier decomposition by further breaking down goods CPI inflation into agricultural, industrial and utility goods CPI inflation. Raw time-series data reveals that agricultural CPI inflation tends to be the most volatile with industrial CPI inflation being the least volatile (Fig. 8c). Utility goods CPI inflation fluctuated substantially in 2015 and 2016 reflecting the government’s policy to cut the administered electricity prices. Overall, goods CPI inflation tends to be aligned with industrial goods CPI inflation due to its high weight of around 74% (333.1/448.5 in Table 1). The direction of the change in inflation is partly determined by the agricultural goods price changes because of its volatile nature despite the low weight of around 17% (77.1/448.5).

The regression decomposition analysis confirms that the combination of agricultural and industrial goods CPI inflation can explain almost the entire portions of goods CPI inflation fluctuations in normal times with limited changes in administered prices (Fig. 8d).

Overall findings from the accounting regression of CPI inflation suggest that we should pay close attention to agricultural and industrial goods CPI inflation, which is consistent with either the imported inputs or final goods channel, to better understand aggregate CPI inflation dynamics. This is because the former would also eventually affect domestic consumer prices indirectly via domestic sales of domestically produced goods with imported inputs. In order to evaluate which of these channels are more relevant quantitatively, we move on to CPI forecasting model estimates in the next subsection.

**Fact 3.** Aggregate CPI inflation is mainly driven by goods CPI inflation which, in turn, is mostly driven by agricultural and industrial goods CPI inflation.

### 5.2. CPI inflation forecasting models

Similarly to the case of PPI inflation forecasting models in the preceding section, this section performs a simple comparative analysis of various CPI inflation forecasting models based on in-sample fits across models. We first consider a variant of standard Phillips curve models and then move on to several versions of error correction models (ECM) that consider short-run as well as potential long-run co-integrating relationships among IPI, PPI, and CPI.

Following Chang, Choi, and Park (2016), we apply a variant of the standard Phillips curve model to estimate the aggregate CPI inflation in Korea using the quarterly frequency data:

$$\Delta \ln CPI_t = c + \beta \pi_{t+4}^e + \gamma \widehat{GDP}_t + \delta \Delta \ln IPI_t + \varepsilon_t, \tag{16}$$

where  $\pi_{t+4}^e$  is the one-year-ahead inflation expectation from the survey of consumer expectations,  $\widehat{GDP}_t$  is the estimated output gap from the Hodrick-Prescott (HP) filter method and  $\Delta \ln IPI_t$  is the aggregate import price inflation as used before.

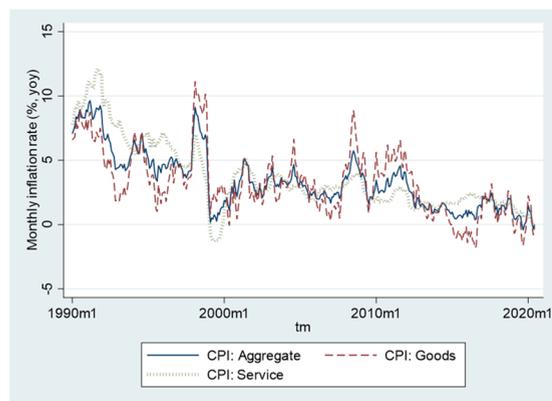
To investigate the role of import prices in determining CPI inflation, we compare the regression results with and without an import price inflation term in a similar vein to Forbes (2019). Column 1 in Table 7 reports the estimation result for the full sample ranging from 2002 Q1 to 2020 Q2 without an import price inflation term. This confirms an important role of the inflation expectation and output gap in determining CPI inflation which supports the validity of the Phillips curve model in Korean economy. The magnitudes of the estimated coefficients suggest that a 1pp increase in one-year ahead inflation expectations is associated with an increase in CPI inflation of 1.34pp while a 1pp increase in the output gap is associated with an increase in CPI inflation of about 0.15pp.

However, as an import price inflation term is included, the estimated coefficient of the output gap term drops substantially and becomes statistically insignificant while the coefficient of the import price inflation term is estimated to be positive and significant (column 2). It is also worth noting that there are significant increases in R-squared values as an import price inflation term is added to the estimation. Qualitatively similar patterns are commonly found in the earlier period (columns 3 and 4) and the later period (columns 5 and 6).<sup>9</sup>

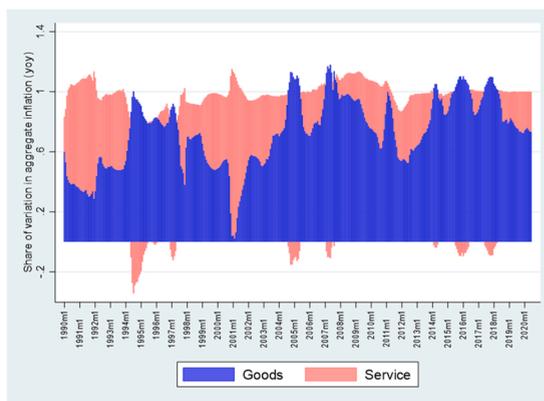
This clearly suggests that augmenting the standard Phillips curve model by explicitly taking into account import prices could substantially improve the estimated fit of CPI inflation dynamics. This is illustrated in Fig. 9a and b implying a significant role of import prices in determining CPI inflation but a rather weak relationship between domestic economic conditions and CPI inflation.

Given that the Phillips curve is rather flat once import prices are controlled for, we may consider alternative error correction models (ECMs) of inflation forecasts where the short-run as well as a potential co-integrating relationship between CPI and IPI are explicitly accounted for:

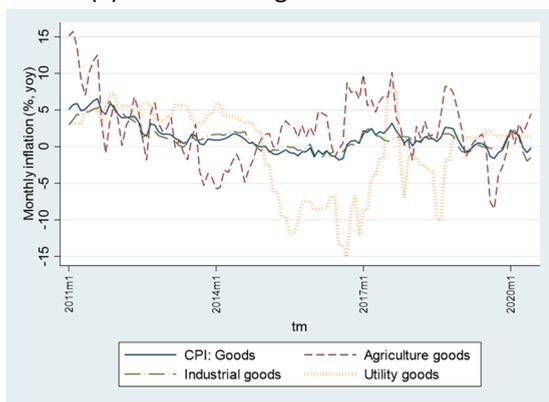
<sup>9</sup> Adding lagged CPI inflation terms gives quantitatively similar results. Moreover, similarly to the case of PPI estimation, we also estimated the model using GMM estimator with lagged independent variables as IVs to account for the potential endogeneity issue, and there is no major difference in the results.



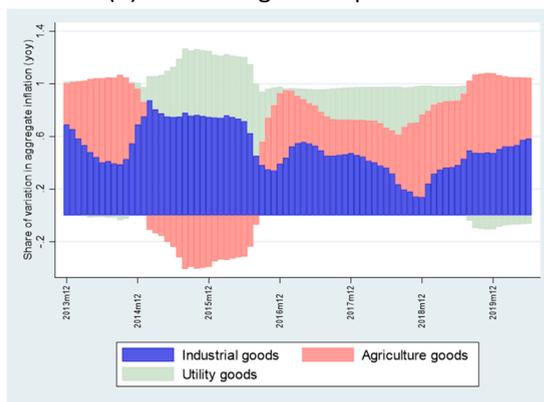
(a) CPI inflation: goods and service



(b) Accounting decomposition



(c) CPI goods inflation by sectors



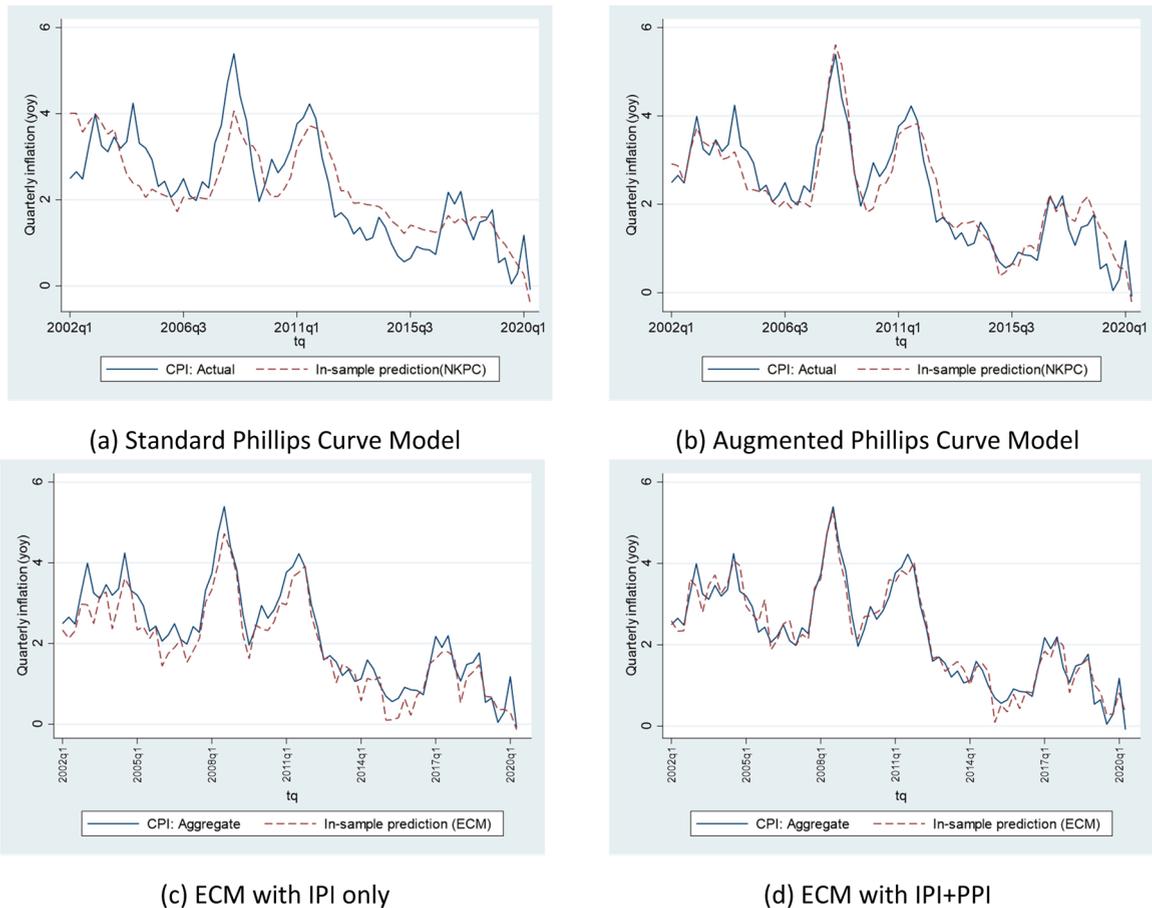
(d) Accounting decomposition

**Fig. 8.** Monthly CPI Inflation: Time-series Evolution and Accounting Decomposition. Note: These figures show the evolution of the monthly aggregate consumer price inflation, broken down by goods and service consumer price inflation (panel (a)) and the regression decomposition result from the specification expressed in Eq. (15) (panel (b)); the evolution of the monthly goods consumer price inflation, broken down by sector-level goods price inflation (panel (c)) and the regression decomposition result from the specification expressed in Eq. (15) (panel (d)). Although the sum of the estimated coefficients should be equal to 1, it may not be exactly equal to 1 in some periods because the weights are not perfectly updated.

**Table 7**  
Simple Phillips Curve Estimation Results: CPI Inflation.

| Inflation expectation  | (1)             | (2)        | (3)             | (4)       | (5)             | (6)       |
|------------------------|-----------------|------------|-----------------|-----------|-----------------|-----------|
|                        | 2002 Q1-2020 Q2 |            | 2002 Q1-2011 Q4 |           | 2012 Q1-2020 Q2 |           |
|                        | 1.336 ***       | 1.046 ***  | 0.807 ***       | 0.658 *** | 0.891 ***       | 0.884 *** |
|                        | (0.117)         | (0.069)    | (0.212)         | (0.090)   | (0.140)         | (0.122)   |
| GDP gap                | 0.148 *         | 0.020      | 0.084           | 0.017     | 0.170 **        | -0.015    |
|                        | (0.075)         | (0.043)    | (0.092)         | (0.036)   | (0.074)         | (0.053)   |
| Import price inflation |                 | 0.058 **   |                 | 0.056 *** |                 | 0.039 *** |
|                        |                 | (0.005)    |                 | (0.005)   |                 | (0.007)   |
| Constant               | -1.976 ***      | -1.141 *** | 0.210           | 0.443     | -1.120 ***      | -0.981 ** |
|                        | (0.348)         | (0.234)    | (0.721)         | (0.340)   | (0.403)         | (0.356)   |
| R-squared              | 0.667           | 0.880      | 0.309           | 0.862     | 0.602           | 0.768     |
| OBS                    | 74              | 74         | 40              | 40        | 34              | 34        |

Note: This table summarizes CPI inflation forecasting model estimation results based on the simple Phillips curve model approach, specified in Eq. (16). Columns (1) and (2) includes an entire sample period from 2002 to 2020; Columns (3) and (4) considers an earlier sample period from 2002 to 2011; Columns (5) and (6) covers the latter sample period from 2012 to 2020; Columns (1), (3), and (5) correspond to a standard Phillips curve model without an import price term, whereas columns (2), (4), and (6) are from an augmented Phillips curve model with an import price term. Robust standard errors are in parentheses. \*: significant at 10% level; \*\*: significant at 5% level; \*\*\*: significant at 1% level.



**Fig. 9.** Quarterly CPI Inflation: Actual and Model Estimates. Note: These figures illustrate CPI inflation forecasting model estimation results. They compare the actual CPI inflation with the predicted CPI inflation from the standard Phillips curve model, specified in Eq. (16), without an import price term (panel (a)) or with the predicted CPI from the augmented Phillips curve model with an import price term (panel (b)); CPI inflation forecasting model estimation results based on the error correction model (ECM) approach, specified in Eq. (17) (panel (c)) and 18 (panel (d)).

$$\Delta \ln CPI_t = c + \alpha(\ln CPI_{t-1} - \beta_1 \ln IPI_{t-1}) + \gamma_1 \Delta \ln IPI_t + \varepsilon_t, \tag{17}$$

where  $\alpha$  is the error correction coefficient that reflects the speed of adjustment towards the long-run relationship and the error correction term representing the long-run relationship is inside the parenthesis. The short-run effect of IPI inflation on CPI inflation can be measured through the estimate of the coefficient,  $\gamma_1$ . Excluding import price terms  $-\beta_1 \ln IPI_{t-1}$  and  $\gamma_1 \Delta \ln IPI_t$ —reduces the formula to the AR(1) model of CPI in log.

Alternatively, PPI inflation terms can be also added along with IPI inflation terms in an extended version of ECMs as in:

$$\Delta \ln CPI_t = c + \alpha(\ln CPI_{t-1} - \beta_1 \ln IPI_{t-1} - \beta_2 \ln PPI_{t-1}) + \gamma_1 \Delta \ln IPI_t + \gamma_2 \Delta \ln PPI_t + \varepsilon_t. \tag{18}$$

Table 8 summarizes estimation results from AR(1), baseline ECM with IPI inflation only, and extended ECM, respectively in columns 1–3. The estimated error correction coefficient of  $-0.019$  from the AR(1) model in column 1 indicates that the CPI level series is very close to the I(1) series. The baseline ECM estimation result in column 2 which explicitly accounts for the effect of IPI inflation confirms the presence of a co-integrating relationship as reflected in the negative and statistically significant error correction coefficient estimate. Moreover, the short-run coefficient estimate of the IPI inflation term suggests that a 10pp increase in IPI inflation is passed onto CPI inflation by 0.73pp in a quarter and the long-run coefficient estimate reveals that it will eventually lead to an increase in CPI inflation by 3.4pp in the long run.

However, as we consider an extended version of the ECM with PPI inflation on top of IPI inflation, estimated coefficients on IPI inflation terms as well as that on the error correction coefficient become statistically insignificant. However, the short-run relationship with PPI inflation stands out with a positive and statistically significant coefficient estimate—a 10pp increase in PPI inflation leads to a 3.2pp increase in CPI inflation within a quarter, while the long-run relationship being less clear (column 3).

Fig. 9c illustrates that the in-sample fit from the baseline ECM with IPI inflation terms appears to be as good as that from the augmented Phillips curve model with IPI inflation in Fig. 9b. An extended version of the ECM with both IPI and PPI inflation terms

**Table 8**  
AR(1) and ECM Estimation Results (CPI).

| Short-run                     | (1)<br>CPI:AR (1)      | (2)<br>CPI:ECM1        | (3)<br>CPI:ECM2       | (4)<br>CPI:ECM3        | (5)<br>CPI:ECM4        |
|-------------------------------|------------------------|------------------------|-----------------------|------------------------|------------------------|
| $\Delta \ln(PPI)_{it}$        |                        |                        | 0.321 * **<br>(0.063) |                        | 0.324 * **<br>(0.050)  |
| $\Delta \ln(IPI)_{it}$        |                        | 0.073 * **<br>(0.012)  | -0.008<br>(0.018)     |                        |                        |
| $\Delta \ln(EPI)_{it}$        |                        |                        |                       | 0.058 *<br>(0.031)     | -0.001<br>(0.026)      |
| $\Delta \ln(Fuel)_{it}$       |                        |                        |                       | 0.009 *<br>(0.004)     | -0.004<br>(0.004)      |
| Constant                      | 0.090 * **<br>(0.020)  | 0.066 * **<br>(0.017)  | 0.038<br>(0.055)      | 0.036<br>(0.027)       |                        |
| Long-run<br>$\ln(PPI)_{it-1}$ |                        |                        | 0.590<br>(1.347)      |                        | 0.949 *<br>(0.530)     |
| $\ln(IPI)_{it-1}$             |                        | 0.336 * **<br>(0.120)  | 0.076<br>(0.529)      |                        |                        |
| $\ln(EPI)_{it-1}$             |                        |                        |                       | 0.945 * **<br>(0.234)  | 0.273<br>(0.469)       |
| $\ln(Fuel)_{it-1}$            |                        |                        |                       | -0.112<br>(0.073)      | -0.125 *<br>(0.063)    |
| Error Correction coeff        | -0.019 * **<br>(0.005) | -0.021 * **<br>(0.005) | -0.023<br>(0.022)     | -0.041 * **<br>(0.012) | -0.039 * **<br>(0.013) |
| OBS                           | 74                     | 74                     | 74                    | 72                     | 72                     |

Note: This table summarizes CPI inflation forecasting model estimation results based on the error correction model (ECM) approach, specified in Eqs. (17) and (18). Column (1) does not include any import or producer price term that thus reduces to AR(1) model. Column (2) includes aggregate import price index terms only, while column (3) includes both aggregate import and producer price indices. Columns (4) and (5) include external factors (i.e., global brent oil price and major trading partners' average export prices) instead of aggregate import price index. Robust standard errors are in parentheses. \*: significant at 10% level; \*\*: significant at 5% level; \*\*\*: significant at 1% level.

seems to provide an even better in-sample fit (Fig. 9d).

In sum, although the augmented Phillips curve model and the baseline ECM estimates suggest an important role of IPI inflation in the determination of CPI inflation, the extended ECM with an additional PPI inflation term highlights the relevance of PPI inflation which by far outweighs the role of IPI inflation.<sup>10</sup> This strongly suggests that the effect of IPI inflation is completely channeled through PPI inflation which is in turn transmitted to CPI inflation leaving little room for an independent role of IPI inflation on CPI inflation. Thus, we can conclude that the intermediate inputs channel dominates the final goods channel through which import prices affect domestic consumer prices.

More specifically, replacing the aggregate IPI inflation term in Eqs. (17) and (18) with external factors such as average EPI inflation of major trading partners and/or global oil price inflation can reveal a combination of the inflation forecasting model estimates for IPI, PPI, and CPI that have been reported so far. Column (4) in Table 8 provides quantitative implications of changes in external prices on CPI inflation, which turn out to be completely channeled via PPI inflation (column (5)).

Relative performance of respective CPI inflation estimation models is summarized in Table 9 in terms of in-sample root mean squared errors (RMSE). The Standard Phillips curve model (PC) performs the worst followed by AR(1), which is consistent with the previous literature that found even an AR(1) model could outperform the standard Phillips curve model in providing CPI inflation forecasts (e.g., Stock & Watson, 2008). However, the augmented Phillips curve model (Aug. PC) that explicitly incorporates import prices provides an even better fit, thereby confirming the important role of import prices and the declining relevance of domestic economic conditions in CPI inflation determination. Departing from the Phillips curve model, ECM models with IPI inflation only (ECM1) or both IPI and PPI inflation (ECM2) turn out to substantially improve the in-sample fit. For example, RMSE from ECM2 model is 21% smaller than the augmented Phillips curve model (0.33 vs.0.42).

## 6. Conclusion

In this paper, we investigated the role of import prices on domestic price inflation dynamics. We conducted the regression decomposition method in order to identify major sources of variation in aggregate CPI, PPI, and IPI Inflation and confirmed a potential link from import prices to domestic PPI and CPI inflation. In addition, we performed a set of comparative analyses across various inflation forecasting models and estimated the significant role of import prices on PPI and CPI inflation dynamics. In particular, our evidence suggested that the main channel through which import prices affect domestic price inflation is via the IPI-PPI nexus which is consistent with the globalization hypothesis that tries to explain both the observed global inflation synchronization and the flattening of the Phillips curve across the globe.

Our findings in this paper deliver important implications regarding the (in)effectiveness of central banks' monetary policy in

<sup>10</sup> Replacing headline CPI inflation by core CPI inflation yields qualitatively identical results, which are available on request.

**Table 9**  
Comparison of In-Sample Forecast across Estimation Models (CPI).

|                            | PC   | Aug. PC | AR   | ECM1 (IPI only) | ECM2 (IPI+PPI) | ECM3 (EPI+Fuel) | ECM4 (PPI+EPI+Fuel) |
|----------------------------|------|---------|------|-----------------|----------------|-----------------|---------------------|
| RMSE                       | 0.69 | 0.42    | 0.49 | 0.39            | 0.33           | 0.41            | 0.32                |
| RMSE (relative to Aug. PC) | 1.66 | 1.00    | 1.18 | 0.94            | 0.79           | 0.98            | 0.76                |

Note: This table summarizes the comparison of in-sample forecast performance across CPI inflation forecast models. PC, Aug.PC, AR, and ECM denote standard Phillips curve, augmented Phillips curve, autoregressive, error correction model, respectively. ECM1 refers to the baseline ECM model with import price index only, and ECM2 refers to the ECM model with both import and producer price indices. ECM3 and ECM4 include external factors (i. e., global brent oil price and major trading partners' average export prices) instead of aggregate import price index.

managing inflation dynamics. To the extent that import prices are largely determined by exogenous external factors, a dominant role of import prices in determining domestic inflation dynamics suggests that the effect of domestic monetary policy on controlling domestic inflation in a small open economy in the era of goods market hyper-globalization could be much more limited than previously thought. Going forward, it also suggests that the current rise in inflation around the globe after the Covid19- pandemic, which has been largely driven by imported food and energy price channels, is unlikely to be contained by domestic monetary policy alone.

### Data availability

Data will be made available on request.

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