Appendix to "What's driving inflation: wages, profits, or energy prices?" – speech by Jonathan Haskel, May 2023

This appendix provides additional details of concepts, methods and data, and additional results, in relation to the speech titled "What's driving inflation: wages, profits, or energy prices?" given by Jonathan Haskel at the Peterson Institute for International Economics on 25 May 2023.

Concepts

Gross domestic product (GDP) at market prices in the National Accounts can be calculated in three ways:

- Output approach – the sum of all value added produced by the domestic economy
- Expenditure approach – the sum of all expenditure on final products produced by the domestic economic
- Income approach – the sum of all income earned from production activities in the domestic economy

We will use the expenditure and income approaches, and the components therein, as part of the decomposition of the GDP deflator.

The GDP deflator is the implied deflator from the combination of the estimate of GDP in nominal terms (current prices) and volume terms (chained volume measures). It is, in effect, a composite deflator of all the items in GDP with appropriate weights.

GDP at market prices is equal to gross value added (GVA) at basic prices plus taxes on products, less subsidies on products. This adjustment is called the basic price adjustment. Taxes and subsidies on products relate only to the selling price of products, not to their production, and are (usually) paid by all sectors of the economy, so these are not allocated to sectors.

Income

By the income approach, GVA at basic prices is equal to compensation of employees (CoE), mixed income (MI), gross operating surplus (GOS), and taxes less subsidies on production.

CoE represents all payments to labour, including wages and salaries, bonuses, payments in kind (e.g. perks such as company cars), and employer's social contributions (notably pension contributions and, in the UK, National Insurance contributions). It is calculated before income taxes (and before employee's National Insurance contributions in the UK).

Mixed income covers the income of the self-employed, which is conceptually a mix of both labour and capital income. Ideally, we would separate this into labour and capital income, but by its nature that cannot be done reliably. In international data it is usually reported in combination with gross operating surplus (i.e. GOS+MI), even though it is not all conceptually capital income.

GOS is the balancing item of the production account, calculated as GVA at basic prices minus CoE, MI, and taxes less subsidies on production. Conceptually, GOS is the return on capital, although in practice, since it is calculated by residual, it also captures a range of other factors, such as monopoly rents and measurement error. GOS is gross of consumption of fixed capital (CFC), which is the estimated economic cost of depreciation of capital assets recorded in the National Accounts. After deducting CFC, the remainder is net operating surplus (NOS). For the corporate sector, NOS is the closest concept to 'profit', although as above it is calculated by residual and so in practice can include many factors other than profit.

GOS can be decomposed into the GOS of different institutional sectors: corporations (public and private), government, non-profit institutions serving households (NPISH), and households. The GOS of each of these sectors is described below:

- Corporations – GOS reflects CFC and NOS.
    - CFC – depreciation on the tangible and intangible capital recorded in the National Accounts, including buildings, machinery, ICT equipment, transport equipment, software, R&D, and artistic originals.
    - NOS – conceptually the economic return on the above measured assets and any other assets. In practice, also measurement error.
- Government and NPISH – NOS is assumed to be zero by convention, so GOS is equal only to CFC. CFC is depreciation on the same types of assets as for the corporations sector, but those assets which are owned by the government and NPISH sectors.
- Households – GOS reflects CFC and NOS, mostly in relation to housing assets (dwellings).
    - CFC – depreciation on assets owned by the household sector, which is mostly dwellings. Households who own their houses outright, or through a mortgage, are owner-occupier households – depreciation on these dwellings is CFC in the household sector.

o NOS – mostly the value of owner-occupier dwellings income, also known as imputed rentals. This is conceptually the rental income a household would earn if renting their house to a third-party, instead of occupying it themselves.

In the UK National Accounts, a quarterly 'alignment adjustment' is also included in GOS, allocated to the corporations NOS component. The alignment adjustment reflects differences in the timing of recording of different components of GDP, and is used to reconcile the different measures of GDP on a quarterly basis. The alignment adjustment sums to zero across a calendar year, so does not affect year-on-year comparisons, but can materially affect individual quarters. It reflects (positive or negative) income in the economy, but it is unclear which type of income. Since GOS, and particularly the NOS of corporations component, is the least well-measured income component in GDP (especially in the short run), the alignment adjustment is allocated there by convention. This does not necessarily mean that the income reflected by the alignment adjustment is, in fact, NOS of corporations.

There are also other types of measurement error in the UK National Accounts in the short term. Differences between the levels of GVA estimated via the three approaches to GDP are known as 'statistical discrepancies'. In the long run, all three approach to measuring GDP are balanced as part of a Supply and Use balancing process, and the statistical discrepancies are eliminated. In the short run, differences can persist. The statistical discrepancy on income reflects the fact that the sum of the income components adds up to either more or less than the headline estimate of GDP. As for the alignment adjustment (although for a slightly different reason), this reflects (positive or negative) income, although the source of that is unclear.

How these measurement errors are accounted for in other countries, and how big they are, is unknown. But we suspect they are usually allocated to the GOS component of the income approach to GDP.

Taxes and subsidies are discussed in the speech.

Expenditure

GDP by the expenditure approach is the sum of expenditures on final goods and services. It comprises the following components:

- Household final consumption expenditure – all expenditure on goods and services by households, including owner-occupier housing costs, and financial intermediation services indirectly measured (FISIM). The scope of this is not exactly the same as the scope of the CPI basket, with the aforementioned components being notable differences. Even where the scope is the same, the weights and price indices used may be different between the CPI and National Accounts.

- NPISH final consumption expenditure – by convention, the NPISH sector is assumed to consume its own non-market output.
- Government financial consumption expenditure – by convention, the government sector is assumed to consume its own non-market output.
- Gross capital formation – comprising gross fixed capital formation (GFCF), changes in inventories, and acquisitions less disposals of valuables.
- Exports – covering goods and services, including re-exports (goods imported then exported with no additional processing).
- (less) Imports – since the other components may include imported goods and services, and these do not reflect domestic value added or income, imports are deducted in the expenditure approach to GDP.

Methods

By the income approach to GDP, we can express nominal (current price) GDP as the sum of labour income, capital income, and taxes less subsidies. Imagine that mixed income has been split appropriately into capital and labour income. We can write this as in equation 1:

$$P_V V = WL + RK + TxS \tag{1}$$

Where P_V is the price of GDP, V is real GDP, W is the average unit price of labour (wages), L is the volume of labour, R is the average unit price of capital (rental price), K is the volume of capital, T is taxes on products and production, and S is subsidies on products and production, so TxS is net taxes (taxes less subsidies) on products and production.

Dividing both sides by real GDP, and taking annual percentage changes, gives equation 2:

$$dp_V = s_V^L \underbrace{(dw - (dv - dl))}_{\text{Unit labour costs}} + s_V^K \underbrace{(dr - (dv - dk))}_{\text{Unit capital costs}} + s_V^T \underbrace{(dT - dv)}_{\text{Unit taxes}} - s_V^S \underbrace{(dS - dv)}_{\text{Unit subsidies}} \tag{2}$$

Where terms preceded by d and in lower case represent annual percentage changes. s_V^L is the share of labour income in (current price) GDP in the base period, and equivalently for the share of capital income (s_V^K), taxes (s_V^T) and subsidies (s_V^S). The unit labour costs and unit capital costs terms have been re-arranged such that labour productivity and capital productivity, respectively, have been made explicit.

Time subscripts are omitted for brevity, but unit cost growth of each component is weighted by their shares in GDP in the base period, updating each quarter. For instance, annual growth to 2022 Q3 is weighted by the shares of GDP in 2021 Q3, and annual growth in 2022 Q4 is weighted by the shares of GDP in 2021 Q4. This decomposition is

exactly additive, i.e. the terms on the right-hand side exactly add up to the annual percentage change in the implied GDP deflator, assuming that the shares add up to exactly 100%. This requires that any statistical discrepancies are allocated to some component of income.

Equation 2 is the decomposition used in Charts 3-5 and Table A of the speech. Chart 2 does similarly, but that separates the unit capital costs term further. Figure 6 is a scatterplot of the unit capital costs term and unit subsidies term of this equation, across European countries.

Define total factor productivity (TFP) growth of the economy as real GDP growth less share-weighted growth in the volume of labour and capital inputs. Then, equation 2 can be re-expressed as in equation 3 (which is equivalent to equation 3 in the speech):

$$dp_V = s_V^L dw + s_V^K dr - dtfp + s_V^{TxS}(dTxS - dv)$$

(3)

Where we have combined the taxes and subsidies terms into a net taxes term for convenience. Note that TFP growth reduces GDP inflation, since it enables growth in real GDP for a given volume of inputs, and is thus not inflationary.

Now, from the expenditure approach to GDP, note that we can express nominal GDP as the sum of the components, as described earlier. Each has a price and volume component. Rearranging, we can express household final consumption expenditure (henceforth, consumption) as GDP less the other components (which is to add imports, since it was previously subtracted). This is shown in equation 4:

$$P_C C = P_V V + P_M M - P_X X - P_I I - P_G G$$

(4)

Where P_C, P_V, P_M, P_X, P_I, and P_G are the prices of consumption, GDP, imports, exports, investment (gross capital formation), and government final consumption expenditure (and NPISH final consumption expenditure, which is small so omitted for brevity), respectively. Similarly, C, V, M, X, I, and G are the volumes of consumption, GDP, imports, exports, investment, and government final consumption expenditure, respectively.

Dividing by real GDP, and taking annual percentage changes, the share-weighted price of consumption can be written as the price of GDP, plus the share-weighted price of imports, minus the share-weighted price of the other components, where the shares are in terms of current price GDP. Dividing then by the consumption share of GDP, and re-arranging, the price of consumption can be written as the price of GDP, plus the consumption-share-weighted price of imports relative to the GDP price, minus the consumption-share-

weighted price of the other components relative to the GDP price. This is shown in equation 5:

$$dp_C = dp_V + s_C^M (dp_m - dp_V) - s_C^X (dp_X - dp_V) - s_C^I (dp_I - dp_V) - s_C^G (dp_G - dp_V)$$
$$+ s_C^V \psi$$

(5)

Where s_C^M, s_C^X, s_C^I, s_C^G, and s_C^V are the shares of imports, exports, investment, government final consumption expenditure, and GDP in consumption. For instance, the export share of consumption is current price exports divided by current price consumption. ψ is an error term to capture any index number problems, which arise from the use of chained indices and various statistical discrepancies.

The investment and government consumption terms are usually small and not important for our analysis, so we can combine them into an 'other' term. Assuming that the shares of imports and exports in GDP (and thus in consumption) are similar, i.e. there is close to a trade balance, then we can simplify these terms into a 'terms of trade' term – this is approximately true in the UK data, so done here for brevity in notation, but in practice we will estimate each term with the appropriate shares for all countries. Then this can be written as in equation 6 (which is equivalent to equation 2 in the speech):

$$dp_C = dp_V + s_C^M (dp_M - dp_X) + \psi'$$

(6)

Where ψ' now includes the investment and government terms from equation 5.

Finally we can substitute the decomposition of the GDP deflator from equation 2, in for dp_V in equation 6, which gives equation 7 (which is equivalent to equation 4 in the speech):

$$dp_C = s_V^L dw + s_V^K dr - dtfp + s_V^T (dT - dv) - s_V^S (dS - dv) + s_C^M (dp_M - dp_X) + \psi''$$

(7)

Where all terms are as previously defined, except dp_C which we will now define as CPI inflation instead of the National Accounts consumption deflator. As previously discussed, these are subtly different in scope and measurement, most notably by the exclusion in CPI of the cost of owner-occupied housing costs. Thus ψ'' now also captures the difference between CPI inflation and inflation in the National Accounts consumption deflator. For the US, we continue to use the National Accounts consumption deflator, which is what the Fed focuses on.

The decomposition of consumer price inflation in equation 7 is used for Charts 7-10 and Tables B and C in the speech. It is described in words in the speech.

Data

Chart 2

Data for Chart 2 in the speech are sourced from the UK Office for National Statistics (ONS) GDP tables consistent with the First Quarterly Estimate published on 12 May 2023. While that contains quarterly data up to 2023 Q1, we only use data up to 2022 Q4 in the speech since that is the latest period for the international data used elsewhere in the speech, and early estimates of the income components of GDP are highly uncertain.

This is supplemented with some additional detail on the breakdown of gross operating surplus only available in the Quarterly National Accounts, the latest of which was published on 31 March 2023.

Charts 3-5 and Table A

Data for Charts 3-5 and Table A were downloaded from the OECD website on 17 May 2023. The OECD in turn source these data from the ONS for the UK, the Bureau of Economic Analysis (BEA) for the US, and Eurostat for the euro area.

Chart 6

Data for Chart 6 for all 27 EU countries and Switzerland were downloaded from the Eurostat website on 28 April 2023. Eurostat no longer maintains data for the UK, so this was taken from the data used for Chart 3. The chart shows a scatterplot of the unit subsidies contribution against the unit capital costs contribution, each as in the decomposition of inflation in the GDP deflator, as defined in equation 2 of this appendix. The contributions are calculated quarterly and the average of the contributions in 2022 Q3 and 2022 Q4 are taken and plotted. The result is similar is using the 2022 Q4 data alone.

Charts 7-10 and Tables B and C

Charts 7-10 and Tables B and C use much the same data as described above for Charts 3-5 and Table A, with some additions.

Data on hours worked come from the ONS, Bureau of Labour Statistics (BLS), and Eurostat for the UK, US and euro area respectively. The UK measure is total actual weekly hours worked for all in employment in the UK, sourced from the **Labour Force Survey**. The US measure is total economy hours worked, covering the non-farm business sector, farm sector, non-profits, private households, armed forces, and general government. This is published as part of the **BLS Productivity programme**. The euro-area measure is a total hours worked measure collected from member countries by Eurostat as part of the quarterly national accounts collection. It is domestic concept, covering all industries.

Quarterly estimates of the capital stock are constructed by the author. Annual estimates of the capital stock are taken from the **EU KLEMS database** up to the end of 2019. We extend this forward using the perpetual inventory method, using whole economy gross fixed capital formation from national accounts via OECD, and an assumed depreciation rate based on historic depreciation rates. We convert annual estimates to a quarterly estimate by interpolating linearly between quarters.

Data on the expenditure components of GDP are sourced via the OECD from the ONS for the UK, the Bureau of Economic Analysis (BEA) for the US, and Eurostat for the euro area. Data were downloaded on 17 May 2023.
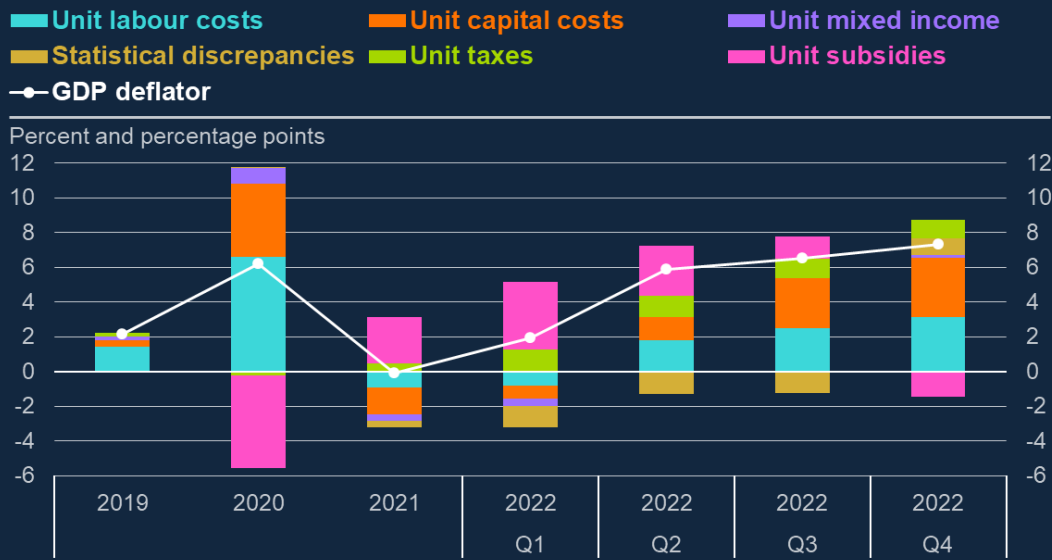
Additional results

Chart 2 of the speech provides a more detailed breakdown of growth in the UK GDP deflator using data from the ONS. This is based on the decomposition in equation 2, but with additional data in the unit capital costs component, and with statistical discrepancies separated.

Chart A1 provides the decomposition of the GDP deflator in the first stack of bars in Chart 2 from the speech, as a time series for 2019-2021 and 2022 Q1 to 2022 Q4. The stack of bars for 2022 Q4 in Chart A1 is equivalent to the first stack of bars in Chart 2 from the speech.

Chart A2 provides the decomposition of unit capital costs in the second stack of bars in Chart 2 of the speech, as a time series for 2019-2021 and 2022 Q1 to 2022 Q4. The stack of bars for 2022 Q4 in Chart A2 is equivalent to the second stack of bars in Chart 2 from the speech. The orange line for unit capital costs in Chart A2 is equivalent to the orange bars for unit capital costs in Chart A1.
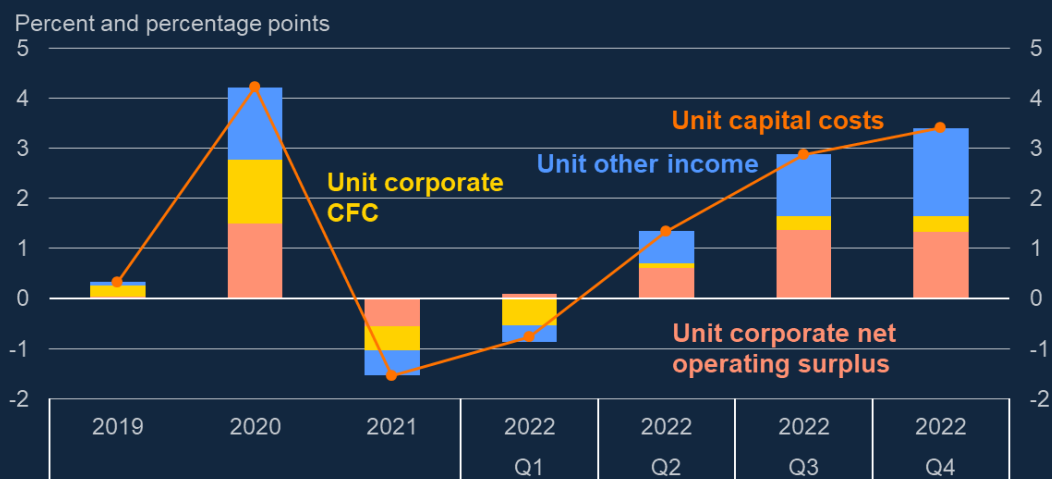
Chart A1: Detailed decomposition of UK GDP deflator growth, 2019 to 2022 Q4 [a]

Legend:
- Unit labour costs
- Unit capital costs
- Unit mixed income
- Statistical discrepancies
- Unit taxes
- Unit subsidies
- GDP deflator

Percent and percentage points

Source: ONS, author's calculations.

(a) This breakdown is the same as in the first stack of bars in Chart 2 of the speech, and the 2022 Q4 stack of bars in this chart is equivalent to the first stack of bars in Chart 2 of the speech. Unit capital costs are separated in Chart A2. Statistical discrepancies includes both the quarterly income alignment adjustment and the statistical discrepancy on income.

Chart A2: Detailed decomposition of UK unit capital costs, 2019 to 2022 Q4 [a]

Percent and percentage points

Labels: Unit capital costs, Unit other income, Unit corporate CFC, Unit corporate net operating surplus

Source: ONS, author's calculations.

(a) This breakdown is the same as in the second stack of bars in Chart 2 of the speech, and the 2022 Q4 stack of bars in this chart is equivalent to the second stack of bars in Chart 2 of the speech. Unit capital costs are separated in Chart A2. CFC stands for consumption of fixed capital, which is the term for depreciation in the National Accounts. Unit other income includes owner-occupied housing income, and the consumption of fixed capital of government and the non-profit institutions serving households (NPISH) sector.