The Concept and Measurement of 'Domestically Generated Inflation'[1]

Willem H. Buiter

University of Cambridge and MPC.

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The opinions expressed are those of the author alone and do not necessarily reflect the views of the Bank of England or of the other members of the Monetary Policy Committee.

I. Introduction.

This note shows what the relationship is between the rate of inflation of the RPI, the rate of inflation of the GDP deflator and 'domestically generated inflation' or *DGI*[2]. What follows is mainly an accounting exercise and a statistical decomposition. This is not a substitute for substantive behavioural analysis, although it is a prerequisite for the latter. There is no presumption that 'domestically generated inflation' is independent of external influences or that 'imported inflation' is independent of domestic economic developments.

The distinction between domestically generated inflation and imported inflation is useful if and to the extent that the behaviour of the two, including their response to shocks, is different from each other, as least in the short and medium term. One characteristic of the approach adopted at the Bank, when modelling inflation, is the key assumption that domestically generated inflation is subject to stickiness or inertia. The existence of these nominal rigidities, which disappear in the long run, means that in order to achieve a reduction in DGI, a temporary increase in unemployment above the natural or equilibrium rate (or NAIRU) and a temporary fall of output below its capacity level (a temporary negative output gap) is required. An augmented Phillips curve, in which the augmentation term, or core inflation, adjusts only gradually to excess demand pressures and to changes in past inflation, is one way, but by no means the only one, of modelling DGI. Imported inflation can adjust without output and employment having to depart from their natural or capacity levels.

Notation:

We adopt the following notation: π^{va}_{gdp} be the rate of GDP deflator inflation; $\tilde{\pi}_{rpi}$ the RPI rate of inflation; $\pi^{va}_{c_d}$ the rate of inflation of the 'domestically produced and domestically sold' private consumption component of the GDP deflator; $\pi^{va}_{c_m}$ the rate of inflation of the deflator of domestic value added created in the production of 'imported' consumer goods; π^{va}_{c} the average rate of inflation of the deflator for value added created in the production of domestically consumed goods and services; $\pi^{va}_{i_d}$ the rate of inflation of the deflator for domestic value added created in the production of domestically sold investment goods; $\pi^{va}_{g_d}$ the rate of inflation of the deflator for domestic value added created in the production of domestically sold government goods and services; $\pi^{va}_{c_x}$ the rate of inflation of the deflator for domestic value added created in the production of exported private consumer goods and services; $\pi^{va}_{i_x}$ the rate of inflation of the deflator for domestic value added created in the production of exported investment goods; $\pi^{va}_{g_x}$ the rate of inflation of the deflator for domestic value added created in the production of exported government goods and services; π^{va}_{x} the

[2] The term 'domestically generated inflation' is due to Mervyn King, who gave the concept prominence in the deliberations of the MPC.

average rate of inflation of the value added deflators of all export components; π_x the rate of inflation of the fob price of exports; π_{r_m} the rate of inflation of world prices of imported raw materials and intermediate inputs; $\tilde{\pi}_{c_m}$ the rate of inflation of domestic sales prices of imported consumer goods and services; π_{c_m} the rate of inflation of world prices of imported consumer goods and services; π_m the average rate of inflation of all world import prices; $\tilde{\pi}_{c_d}$ the rate of inflation of the sales prices of domestically produced and sold consumer goods and services; π_{ulc_c} the growth rate of labour costs per unit of value added (unit labour costs) in the domestic consumer goods sectors producing for the domestic market; π_{up_c} the growth rate of profits (non-wage value-added) per unit of value added (unit profits) in the domestic consumer goods sectors producing for the domestic market; α_{c_d} the share in GDP of domestically produced and domestically sold consumer goods and services; α_{c_m} the share in GDP of value added in the domestic production of 'imported' consumer goods; α_{i_d} the share in GDP of domestically produced and sold investment goods; α_{g_d} the share in GDP of value added in domestically produced and sold government goods and services; α_{c_x} the share in GDP of value added in exported consumer goods and services; α_{i_x} the share in GDP of value added in exported production investment goods; α_{g_x} the share in GDP of value added in exported government goods and services (probably close to zero); γ_{c_d} the share of imported raw materials and intermediates in the total cost of production of 'domestically produced' and sold consumer goods and services; γ_{c_m} the share of imported consumer goods and services in the total domestic sales price of 'imported' consumer goods and services; γ_x the share of imported raw materials and intermediates costs in the fob sales price of exports; β the share of domestically produced consumer goods in total consumption; α_x the share of export value added in GDP; δ the share of world import prices in the RPI; η the share of labour in value added in the domestic consumption goods sectors producing for the domestic market.[3]

II. Domestically Generated Inflation and RPI Inflation.

By domestically generated inflation we mean the contribution of domestic factor price inflation to the rate of inflation of the RPI. It consists of the contribution of domestic factor price inflation to the inflation rate of 'domestically produced' consumer goods and services included in the RPI index plus the contribution of domestic factor price inflation to the cost of 'imported' goods and services included in the RPI. So-called domestically produced and

[3] These shares are all, in principle, time-varying. To prevent notational clutter, the time subscripts are omitted.

consumed goods and services have a significant import component, and so-called imported goods and services have a significant domestic value added component.

By imported inflation we mean the contribution to RPI inflation of import costs, both directly, through the cost of imported consumer goods and services and indirectly through the cost of imported raw materials and intermediate goods and services used in the production of ‘domestically produced’ consumer goods and services).

The rate of RPI inflation, denoted $\tilde{\pi}_{rpi}$ is a weighted average of the rate of inflation of the prices of imported consumer goods and services, $\tilde{\pi}_{c_m}$, and the rate of inflation of the prices of domestically produced and domestically sold consumer goods and services, $\tilde{\pi}_{c_d}$, where the weights are the share of imports in domestic consumption, β, and the share of domestically produced consumer goods in consumption, $1-\beta$, respectively[4].

$$\tilde{\pi}_{rpi} \equiv \beta\tilde{\pi}_{c_m} + (1-\beta)\tilde{\pi}_{c_d} \tag{1}$$

‘Imported’ consumer goods and services included in the RPI have a domestic value added component (distribution, warehousing, wholesaling, retailing etc.). The rate of inflation of the price index of ‘imported’ goods and services included in the RPI, $\tilde{\pi}_{c_m}$, is a weighted average of $\pi_{c_m}^{va}$ and the rate of inflation of the world price (expressed in domestic currency) of imported consumer goods and services, π_{c_m}, where the weights are the ratio of value added to total costs (value added plus import costs), $1-\gamma_{c_m}$, and the ratio of import costs to total costs, γ_{c_m}, respectively.

$$\tilde{\pi}_{c_m} \equiv (1-\gamma_{c_m})\pi_{c_m}^{va} + \gamma_{c_m}\pi_{c_m} \tag{2}$$

The price of ‘domestically produced’ and domestically sold consumer goods and services is not the value added deflator for domestically produced and domestically sold consumer goods and services, because imported intermediate goods and services and raw materials are part of the cost of domestic producers. The rate of inflation of the price of ‘domestically produced’ and sold consumer goods and services, $\tilde{\pi}_{c_d}$, is a weighted average of the inflation rate of the value added of domestically produced consumer goods and services sold on the domestic market, denoted $\pi_{c_d}^{va}$, and the rate of inflation of the world price (in domestic currency) of

[4] Indirect taxes and the mortgage interest component of the RPI are ignored. The RPI concept of this note is therefore closest to the RPIY.

imported intermediates and raw materials, π_{r_m} , where the weights are the ratio of value added to total costs (value added plus import costs), $1-\gamma_{c_d}$, and the ratio of import costs to total costs, γ_{c_d} , respectively.

$$\tilde{\pi}_{c_d} \equiv (1-\gamma_{c_d})\pi^{va}_{c_d} + \gamma_{c_d}\pi_{r_m} \qquad \textbf{(3)}$$

This implies the following expression for the rate of inflation of the RPI:

$$\pi_{rpi} \equiv (1-\beta)(1-\gamma_{c_d})\pi^{va}_{c_d} + \beta(1-\gamma_{c_m})\pi^{va}_{c_m} + (1-\beta)\gamma_{c_d}\pi_{r_m} + \beta\gamma_{c_m}\pi_{c_m} \qquad \textbf{(4)}$$

The average rate of inflation of the value added deflator for domestically produced and consumed consumer goods and services, π^{va}_{c} , is defined as follows:

$$\begin{aligned}\pi^{va}_{c} \equiv\ & \frac{\beta(1-\gamma_{c_m})}{\beta(1-\gamma_{c_m}) + (1-\beta)(1-\gamma_{c_d})}\pi^{va}_{c_m} \\ & + \left(1 - \frac{\beta(1-\gamma_{c_m})}{\beta(1-\gamma_{c_m}) + (1-\beta)(1-\gamma_{c_d})}\right)\pi^{va}_{c_d}\end{aligned} \qquad \textbf{(5)}$$

The average rate of inflation of the value added deflator of domestically consumed production of domestic consumer goods and services, π^{va}_{c} will be called domestically generated inflation or DGI_1, that is,

$$DGI_1 \equiv \pi^{va}_{c} \qquad \textbf{(6)}$$

The average rate of inflation of the world prices (expressed in domestic currency) of all imports, π_m , is defined as follows:

$$\pi_m \equiv \frac{\beta\gamma_{c_m}}{\beta\gamma_{c_m} + (1-\beta)\gamma_{c_d}}\pi_{c_m} + \left(1 - \frac{\beta\gamma_{c_m}}{\beta\gamma_{c_m} + (1-\beta)\gamma_{c_d}}\right)\pi_{r_m} \qquad \textbf{(7)}$$

Equation (4) can be now be rewritten as.

$$\pi_{rpi} \equiv (1-\delta)\pi_c^{va} + \delta\pi_m \quad \textbf{(8)}$$

where

$$\delta \equiv (1-\beta)\gamma_{c_d} + \beta\gamma_{c_m} \quad \textbf{(9)}$$

The expression $1 - \delta \equiv (1-\beta)(1-\gamma_{c_d}) + \beta(1-\gamma_{c_m})$ is the total weight of domestic value added inflation in RPI inflation. It consists of the sum of the *direct* weight of domestic value added, $(1-\beta)(1-\gamma_{c_d})$, the share of domestically produced consumer goods and services in total consumption, *1 - β*, times the share of domestic value added in the total cost of producing 'domestically produced' consumer goods and services, $1 - \gamma_{c_d}$, and the *indirect* weight of domestic value added, $\beta(1-\gamma_{c_m})$, the share of imported consumption in total consumption, *β*, times the share of domestic value added in the total cost of producing 'imported' consumer goods and services, $1 - \gamma_{c_m}$.

The expression $\delta \equiv (1-\beta)\gamma_{c_d} + \beta\gamma_{c_m}$ is the total weight of the inflation of world import prices in RPI inflation. It consists of the sum of the *direct* weight of consumer imports, $\beta\gamma_{c_m}$, the share of imported consumer goods and services in total consumption, *β*, times the share of imports in the total cost of producing 'imported' consumer goods and services, γ_{c_m} , and the *indirect* weight of imports, $(1 - \beta)\gamma_{c_d}$, the share of domestically produced and sold consumer goods and services in total consumption, *1 - β*, times the share of domestic value added in the total cost of producing 'domestically produced and sold' consumer goods and services, γ_{c_d}

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Domestically generated inflation is in turn the weighted sum of the growth rate of labour costs per unit of value added (unit labour costs) in the domestic consumer goods sector producing for the domestic market, π_{ulc_c} and the growth rate of profits (non-wage value-added) per unit of value added (unit profits) in the domestic consumer goods sector producing for the domestic market, π_{up_c} , where *η* is the share of labour in value added.

$$\pi_c^{va} \equiv (1-\eta)\pi_{ulc_c} + \eta\pi_{up_c} \quad \textbf{(10)}$$

III. The GDP deflator and the RPI.

By definition, the rate of inflation of the GDP deflator is a weighted average of the rates of inflation of the components of GDP:

$$\pi^{va}_{gdp} \equiv \alpha_{c_d}\pi^{va}_{c_d} + \alpha_{c_m}\pi^{va}_{c_m} + \alpha_{c_x}\pi^{va}_{c_x} + \alpha_{i_d}\pi^{va}_{i_d} + \alpha_{i_x}\pi^{va}_{i_x} + \alpha_{g_d}\pi^{va}_{g_d} + \alpha_{g_x}\pi^{va}_{g_x}$$

$$\text{where} \tag{11}$$

$$\alpha_{c_d} + \alpha_{c_m} + \alpha_{c_x} + \alpha_{i_d} + \alpha_{i_x} + \alpha_{g_d} + \alpha_{g_x} \equiv 1$$

By definition, the following relation holds:

$$\frac{(1 - \beta)(1 - \gamma_{c_d})}{\beta(1 - \gamma_{c_m})} \equiv \frac{\alpha_{c_d}}{\alpha_{c_m}} \tag{12}$$

It follows that the general relationship between the RPI rate of inflation and the rate of inflation of the GDP deflator is as given in (13).

$$\begin{aligned}\tilde{\pi}_{rpi} \equiv & \left(\frac{1-\delta}{\alpha_{c_d} + \alpha_{c_m}}\right)[\pi^{va}_{gdp} - \alpha_{i_d}\pi^{va}_{i_d} - \alpha_{g_d}\pi^{va}_{g_d}] + \delta\pi_m \\ & - \left(\frac{1-\delta}{\alpha_{c_d} + \alpha_{c_m}}\right)[\alpha_{c_x}\pi^{va}_{c_x} + \alpha_{i_x}\pi^{va}_{i_x} + \alpha_{g_x}\pi^{va}_{g_x}]\end{aligned} \tag{13}$$

Let α_x be the total share of export value added in GDP, that is,

$$\alpha_x \equiv \alpha_{c_x} + \alpha_{i_x} + \alpha_{g_x} \tag{14}$$

We define the average rate of inflation of the export value added deflators as follows

$$\pi^{va}_x \equiv \frac{\alpha_{c_x}}{\alpha_x}\pi^{va}_{c_x} + \frac{\alpha_{i_x}}{\alpha_x}\pi^{va}_{i_x} + \frac{\alpha_{g_x}}{\alpha_x}\pi^{va}_{g_x} \tag{15}$$

The average rate of inflation of the value added deflators of the domestically sold components of GDP is defined as follows:

$$\pi_d^{va} \equiv \left(\frac{\alpha_{c_d} + \alpha_{c_m}}{1 - \alpha_x} \right) \pi_c^{va} + \frac{\alpha_{i_d}}{1 - \alpha_x} \pi_{i_d}^{va} + \frac{\alpha_{g_d}}{1 - \alpha_x} \pi_{g_d}^{va} \tag{16}$$

The expression in (13) can be simplified considerably if we make the simplifying assumption that the rate of inflation of the value added deflator for domestic consumption equals the average rate of inflation of the value added deflators of all domestically sold components of GDP, that is

$$\pi_c^{va} = \pi_d^{va} \tag{17}$$

With this assumption, the RPI rate of inflation can now be written as

$$\tilde{\pi}_{rpi} = \left(\frac{1 - \delta}{1 - \alpha_x} \right) \pi_{gdp}^{va} + \delta \pi_m - \left(\frac{1 - \delta}{1 - \alpha_x} \right) \alpha_x \pi_x^{va} \tag{18}$$

We now make the further simplifying assumption that the share of export value added in GDP equals the direct and indirect share of imported goods the RPI index,

$$\delta = \alpha_x \tag{19}$$

With these assumptions, the relation between RPI inflation and GDP inflation takes the following very simple form:

$$\tilde{\pi}_{rpi} = \pi_{gdp}^{va} + \alpha_x (\pi_m - \pi_x^{va}) \tag{20}$$

or, equivalently,

$$\tilde{\pi}_{rpi} = (1 - \alpha_x) \pi_{gdp}^{va} + \alpha_x \pi_m + \alpha_x (\pi_{gdp}^{va} - \pi_x^{va}) \tag{21}$$

The RPI rate of inflation differs from the GDP deflator rate of inflation only if the rate of inflation of import prices differs from the inflation rate of the export value added deflator. If import prices are rising faster than the export GDP deflator (if the 'terms of trade' worsen), the RPI will be rising faster than the GDP deflator. Exchange rate depreciation will therefore not in and of itself make the RPI inflation rate higher than the rate of inflation of the GDP deflator. That will happen only if the depreciation causes the domestic currency price of imports to rise faster than the domestic currency value of the export value added deflator.

In many simple analytical models, the assumption is often made that the rate of inflation of the export value added deflator is the same as the rate of inflation of GDP deflator as a whole, that is, it assumes

$$\pi_{gdp}^{va} = \pi_x^{va} \qquad \textbf{(22)}$$

With this assumption, equations (20) and (21) become equations (23) and (24), respectively.

$$\tilde{\pi}_{rpi} = \pi_{gdp}^{va} + \alpha_x(\pi_m - \pi_{gdp}^{va}) \qquad \textbf{(23)}$$

$$\tilde{\pi}_{rpi} = (1-\alpha_x)\pi_{gdp}^{va} + \alpha_x \pi_m \qquad \textbf{(24)}$$

With $\alpha_x \approx 0.19$, as is approximately the case in the UK, such a simplification can have quantitatively significant effects.

Whenever the rate of inflation of the export value added deflator is less than (greater than) the rate of inflation of the GDP deflator as a whole, the RPI inflation rate will be understated (overstated) relative to the rate of inflation of the GDP deflator if the simplification in (22) is adopted. Under current conditions, it would therefore lead to a downward bias in the RPI inflation estimate.

Note that the price of exports (the fob price) is not the value added deflator for exports, because imported intermediate goods and services and raw materials are part of the cost of export producers. The rate of inflation of the fob price of exports, π_x is a weighted average of π_x^{va} and the rate of inflation of imported intermediates and raw materials, π_{r_m} , where the weights are the ratio of value added to total costs (value added plus import costs), $1-\gamma_x$, and the ratio of import costs to total costs, γ_x, respectively.

$$\pi_x \equiv (1-\gamma_x)\pi_x^{va} + \gamma_x \pi_{r_m} \quad \textbf{(25)}$$

This produces the following equation,

$$\begin{aligned}\tilde{\pi}_{rpi} = &\left(\frac{1-\delta}{1-\alpha_x}\right)\pi_{gdp}^{va} + \left((1-\beta)\gamma_{c_d} + \left(\frac{1-\delta}{(1-\alpha_x)(1-\gamma_x)}\right)\alpha_x\gamma_x\right)\pi_{r_m} + \beta\gamma_{c_m}\pi_{c_m} \\ &- \left(\frac{1-\delta}{(1-\alpha_x)(1-\gamma_x)}\right)\alpha_x\pi_x\end{aligned} \quad \textbf{(26)}$$

If $\delta = \alpha_x$ and if all imports have the same rate of inflation, equation (26) simplifies to

$$\tilde{\pi}_{rpi} = \pi_{gdp}^{va} + \frac{\alpha_x}{1-\gamma_x}(\pi_m - \pi_x) \quad \textbf{(27)}$$

or, equivalently,

$$\tilde{\pi}_{rpi} = (1 - \frac{\alpha_x}{1-\gamma_x})\pi_{gdp}^{va} + \frac{\alpha_x}{1-\alpha_x}\pi_m + \frac{\alpha_x}{1-\gamma_x}(\pi_{gdp}^{va} - \pi_x) \quad \textbf{(28)}$$

The expression $\pi_m - \pi_x$ is the proportional rate of decline of the conventionally measured terms of trade, the relative price of exports (fob) and imports (cif).

IV. Accounting and Economics: A Caveat.

The exposition in Section II was a pure accounting exercise. No behavioural assumptions are involved and, in the absence of measurement errors, equations (1) through (10) hold as identities. This means, in particular, that the weights $1 - \delta$ and δ of domestically generated inflation and imported inflation, respectively, should not be estimated but calculated directly, at each point in time, using import shares in consumption and the input-output tables. Estimation of dynamic relationships becomes important when we try to model, say, the response of the domestic currency price of imports, P_m to changes in the foreign currency price of imports, P_m^* or to changes in the nominal exchange rate, E. The evidence on limited pass-through certainly suggests that the Law of One Price ($P_m = EP_m^*$) or its rate of growth version, ($\pi_m = \epsilon + \pi^*_m$, where ϵ is the proportional rate of depreciation of the currency and π^*_m is the world rate of inflation of import prices) does not hold with any great reliability, even in the long run.

The behaviour of π_{ulc_c} and of π_{up_c} is determined by the behaviour of money wages, labour productivity and profit margins. Two points are worth making, however. First, the growth rate of unit labour costs and of unit profits in the domestic consumer goods sector producing for the domestic market may be sector-specific, that is, it may be different from that of the other sectors of the economy and from the economy-wide average. Second, it is important to note, that δ understates the total impact of foreign inflation (and of external influences generally) on RPI inflation. Money wage inflation is a function, among other things, of the anticipated future behaviour of the RPI, which has an import component. Wage settlements and wage drift are a function of the relative bargaining power of employers and workers, and this will be influenced by external competitive pressures in import-competing and exporting industries. If the national labour market is reasonably integrated, even the non-traded or sheltered industries will be influenced by national wage developments that are influenced by the externally exposed sectors. Labour productivity is procyclical, and the cycle is partly driven by external demand. The behaviour of profit margins in the domestic consumer goods sector is influenced by the behaviour of competitive import prices.

Import prices too will not in general be independent of domestic economic developments. Even if the foreign currency price of imports is exogenous to the country under consideration, the exchange rate will be influenced by domestic policies and other domestic shocks and developments. A larger country may also influence the world price of its importables. The pricing behaviour outlined in this note is therefore but one component of a complete dynamic general equilibrium model of the UK economy.

A simple model of unit labour cost inflation, derived from an augmented Phillips curve is the following. First, note that,

$$\pi_{ulc_c} \equiv \pi_{w_c} - \theta_c \qquad \textbf{(29)}$$

where $\pi_{w_{c_d}}$ is the growth rate of money wages in the domestic consumer goods sector producing for the domestic market and θ_c is the actual average growth rate of labour productivity in that sector.

A typical Phillips curve makes the current rate of money wage inflation a decreasing function of the excess of the actual unemployment rate, *u*, over the natural rate of unemployment, u_N. Two common 'augmentation terms' are the target growth rate of real wages, $\bar{\theta}_c$, and the augmentation term in the Phillips curve, or 'core' inflation. Consider the case where core inflation is just last period's expectation of the current rate of inflation, $\tilde{\pi}^e_{rpi}$.

$$\pi_{w_c} = \tilde{\pi}_{rpi}^{e} + \overline{\theta}_c - \psi(u - u_N) \qquad \psi > 0 \tag{30}$$

An implicit assumption in our model appears to be that the inflation rate of unit profits equals the inflation rate of unit labour costs,

$$\pi_{ulc_c} = \pi_{up_c} \tag{31}$$

If equation (31) holds, it follows that

$$DGI_1 = \pi_{ulc_c} \tag{32}$$

While this is a powerful simplification (it implies that profit and labour shares are constant), it is clearly counterfactual. Frequent discussions by the MPC of the behaviour of margins suggests that this assumption is in urgent need of relaxation.

If we assume that (31) holds, domestically generated inflation is given by:

$$\pi_c^{va} = \tilde{\pi}_{rpi}^{e} + \overline{\theta}_c - \theta_c - \psi(u - u_N) \tag{33}$$

The distinction between domestically generated inflation and imported inflation now becomes quite slippery, with rational expectations, $\pi_{rpi}^{e} = (1-\delta)\left(\pi_c^{va}\right)^e + \delta\pi_m^e$ and

$$\pi_c^{va} = (1-\delta)\left(\pi_c^{va}\right)^e + \delta\pi_m^e + \overline{\theta}_c - \theta_c - \psi(u - u_N) \tag{34}$$

A possibly more appropriate definition of DGI could be obtained by stripping out the influence on wage inflation of (expected) import price inflation. I will call this DGI_2:

$$DGI_2 \equiv \frac{1}{1-\delta} DGI_1 - \frac{\delta}{1-\delta}\pi_m^e$$
$$\equiv \frac{1}{1-\delta}\pi_c^{va} - \frac{\delta}{1-\delta}\pi_m^e \qquad \textbf{(35)}$$

With this definition

$$\tilde{\pi}_{rpi} = (1 - \delta)^2 DGI_2 + \left(1 - (1 - \delta)^2\right)\pi_m + (1 - \delta)\delta(\pi_m^e - \pi_m) \qquad \textbf{(36)}$$

When expectations are realised, this reduces to

$$\tilde{\pi}_{rpi} = (1 - \delta)^2 DGI_2 + \left(1 - (1 - \delta)^2\right)\pi_m \qquad \textbf{(37)}$$

With this modification, the weight in RPI inflation of DGI_2 , is of course smaller that with DGI_1 .